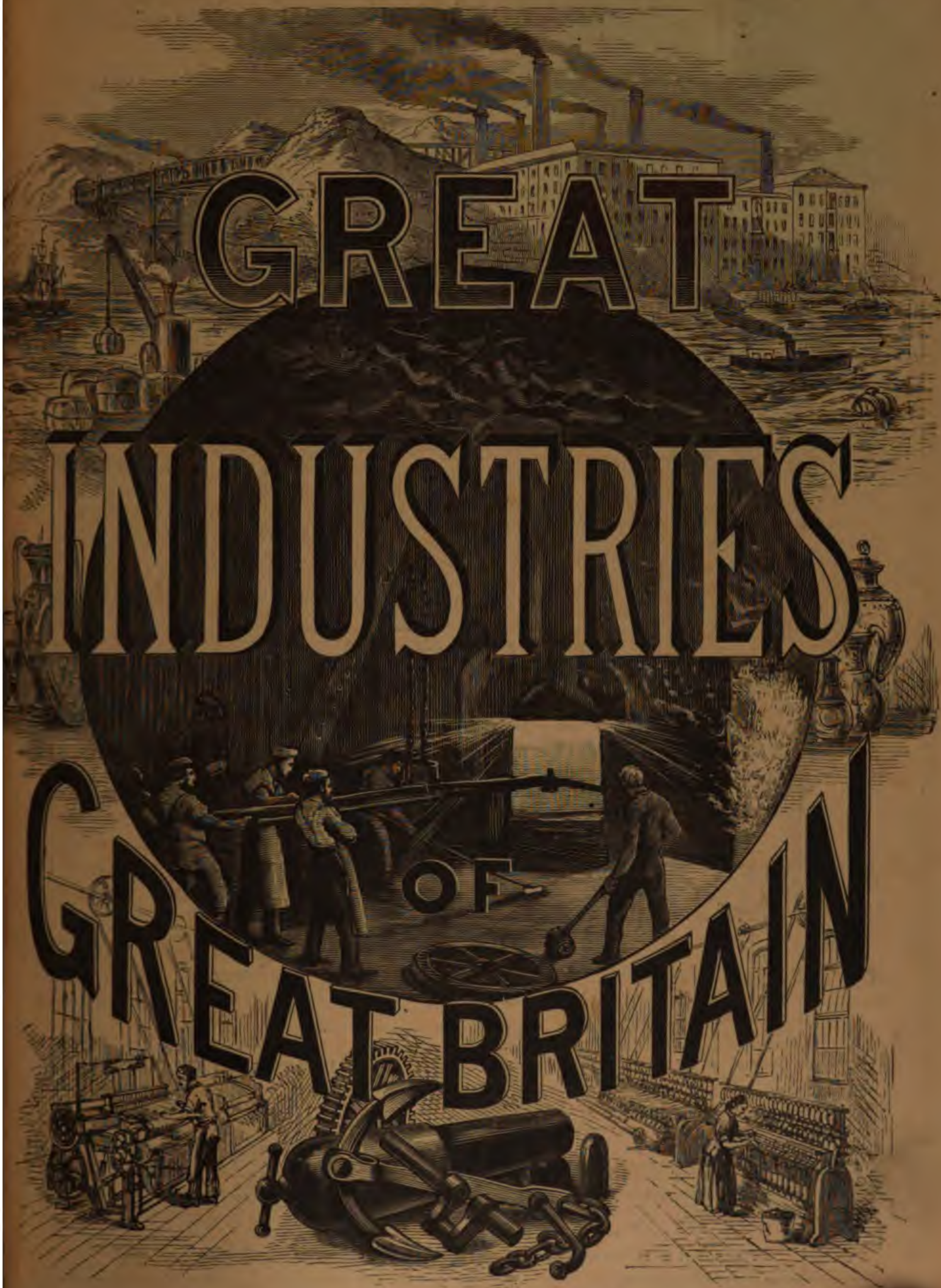
Part 21. *(To be Completed in 30 Parts.)* Price 7d.



Frontispiece.

IN A CUTLER'S SHOP.

GREAT INDUSTRIES

OF

GREAT BRITAIN.

* * *

ILLUSTRATED.

CASSELL & COMPANY, LIMITED:

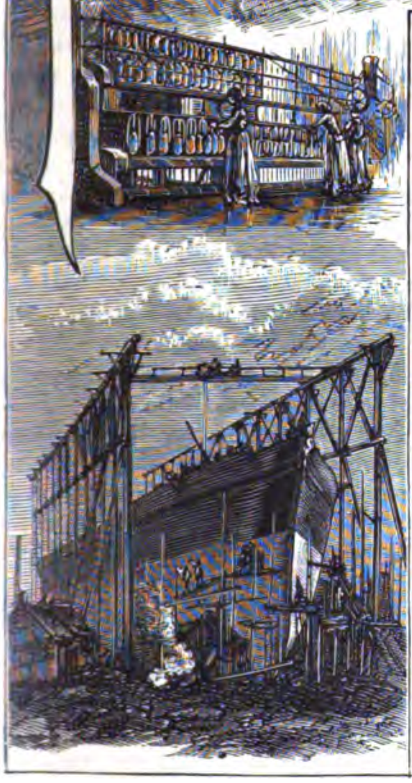
LONDON, PARIS, NEW YORK & MELBOURNE.

CONTENTS.

Fibre of Cotton Wool. (*Magnified.*)

LIST OF ILLUSTRATIONS.

THE MIXED CLOTH HALL, LEEDS.



IRON AND STEEL.—XXI.

BIG GUNS: THEIR HISTORY.

By William Dundas Scott-Moncrieff, C.E.

HUMAN nature, when subjected to the excitement and temptations of war, seems to have been very much the same in all ages, and there is every reason to suppose that the men who were engaged in pre-historic warfare availed themselves of whatever lay nearest at hand to inflict destruction upon their enemies. If this supposition is correct, it is highly probable that in certain Eastern countries "incendiary projectiles" of some sort were of the most remote antiquity; and there is also good ground for supposing that they were obtained direct from the store-house of nature. It is believed by those who have investigated this subject that naphtha, a word which is derived from Nafata (the Persian "to exude"), was first of all employed in warfare in its crude state, and that afterwards it became a principal ingredient in the composition of Greek fire. The method of making this particular compound was long retained as an inviolable secret, and although it appears to have been divulged, and afterwards to have become widely known, all record of how it was made has since been lost. It is said to have been the invention of a certain Callinicus, a Syrian engineer, who, although he was a Mohammedan himself, imparted his invention to the Romans, who were then the possessors of Constantinople, and who made use of the discovery to protect themselves against the attacks of the Saracens. Upon the occasion of a great sea-fight, no fewer than 30,000 Turks are stated to have been destroyed by the use of the new and horrible agent; and during the long period which elapsed from its first introduction in the seventh century to the final and successful siege of Constantinople by the Saracens in 1453, it seems to have played so important a part that the capital of the Eastern Empire, during that long period,

is said to have been preserved by its constant employment. It was by no means confined to the defence of Constantinople, but seems to have been extensively used, in some form, throughout Europe during the warfare of the fourteenth century. Then, in the words of Gibbon, "the scientific or casual compound of nitre, sulphur, and charcoal effected a new revolution in the art of war and the history of mankind." It is here that we come upon a complete revolution in the application of "incendiary projectiles," and discover the necessity of an entirely new apparatus in order to render the discovery available. In most improvements upon the arts of civilisation the progress has been more or less gradual, but in this sudden change which took place in the practice of warfare the invention of guns must have sprung into existence almost as rapidly as the startling discovery which made them necessary.

It is quite certain that nearly all the substantial improvements which followed upon the first application of gunpowder, down to the end of the last century, were made by Europeans; but it seems equally clear that we must look to the well-known ingenuity of a very different race for the original discovery. We are informed, upon the authority of a certain Father Amyot, that stone mortars and stone balls were used in China so early as the eighth century, and it is generally admitted that the Chinese were the first inventors of gunpowder. There were no international patent laws in those days, and however interesting it may be, from an antiquarian point of view, to trace the relative merit or demerit of the country that first introduced an agent so horribly disruptive of the brotherhood of man, it is sufficient for our present purpose to trace the history of the invention as best we can, without much fear of trampling upon the susceptibility of the original inventor.

An apparatus in some way resembling our modern notions of a cannon, followed immediately upon the discovery of gunpowder; but the first efforts to produce a practical weapon seem to have taken an extraordinary shape. Some persons suppose that Schwartz, the chemist whom the Germans claim to have been the inventor of gunpowder, suggested the model of the first mortars. They were so much wider at the muzzle than the breech, that the mortar in which he pounded his materials is said to have been the pattern after which they were made.

There are many vague allusions to the use of gunpowder so early as the thirteenth century, both among the Moors, and, at a still more remote period, in Hindostan; but it is not until the fourteenth century that we find the new discovery had taken a firm hold upon the practice of war. Probably the principal objection to the use of *Ballista* and *Catapulta* lay in their great unwieldiness, which precluded their employment in any service but that of a protracted siege. If the story is true that Edward I. besieged Stirling Castle with engines which were capable of throwing stones weighing 300lbs., then there is good reason for supposing that such an apparatus was quite as powerful as the cannon that superseded it. The immense superiority of the new weapon in reduced bulk and facility of transit was probably the chief reason for its being so rapidly adopted.

While there is ample evidence to be found among contemporary chroniclers of an extensive use of artillery during the fourteenth century, some caution must be exercised in drawing conclusions from the statements made as to the number of guns employed upon certain celebrated occasions. Froissart, for instance, relates that at the siege of St. Malo, in 1378, the English employed as many as 400 cannon. If these were taken to be anything like the size of some well-known guns of that period, such as the famous "Mons Meg," the siege-train in question must have been as formidable as the artillery of our own day. It appears, however, that cannon was used as a generic term for almost every sort of fire-arm, and it is probable that a large proportion of the 400 cannon referred to could have been carried by two men to each. Towards the close of the following century, the Scots seem to have possessed something in the form of field artillery—a branch of the service which has only been developed successfully in very recent times, owing to the difficulties that lay in the way of its being made sufficiently light and portable for the rapid transit that is essential to its efficiency. There is an Act of the Scots Parliament of this period which runs as follows:—"It is thocht speidful that the King mak requeist to certain of the great barrons of the land that are of any myght to mak carts of weir, and in ilk cart twa gunnis, and ilk ane to have twa chalmers, with the remanent of the graith that effeirs thereto, and we cunnand [with cunning] man to shute thame." In 1481, artillery expanded into a variety of ordnance that would puzzle the present authorities at Woolwich if they got an order to manufacture them. Edward IV. issued a proclamation in which were mentioned *bombardos*, *canones*, *culverynes*, *fowelers*, and *serpentynes*. These seem to have been names applied to guns, blunder-

busses, and cannon, few specimens of which exist in the present day; but it is different with the largest class, many of which have survived the ravages of time and the battle-field. These are represented by a few specimens of immense interest, which are a positive record of the state of the art of working in iron at the time at which they were made. Among the most famous of these is "Mons Meg." One account of the origin of this monster gives it out to have been made at Mons, in Hainault; and another attributes it to the work of two brothers named M'Kim, who presented it to James II. of Scotland at the siege of Thrieve Castle. Long after the peaceable union of the two kingdoms it was removed to England, but was restored at the request of Sir Walter Scott, and may now be seen at Edinburgh Castle. Wherever it was made, "Mons Meg" remains a marvel of workmanship in the light of the available appliances of the fifteenth century, and its dimensions—13 feet in length and 20 inches in calibre—are by no means insignificant, even when compared with the giant productions of our modern arsenals.

At this period there seems to have been very much the same sort of rivalry going on among the nations of Europe, as to which of them could turn out the biggest gun, as is going on at the present day. Just as kings of the nineteenth century entertain each other upon great occasions by firing off the most alarming salvoes, so among the courtesies of three hundred years ago we find Charles V. presenting Henry VIII. with the imposing gift of a piece of ordnance, which can still be seen at Dover Castle. It is 24 feet long, and has received the nickname of Queen Elizabeth's pocket-pistol. As the art of casting in England at that time was very backward, we are perhaps justified in looking to the broad hint of superiority so naïvely suggested in this gift as the foundation of many improvements which followed. In the Artillery Museum at Woolwich there is a fine specimen of early ordnance of the time of Mahomet II., bearing the date 1464, which was presented to this country by the Sultan in 1868; and here and there throughout Europe there are cannon which convey a clear idea of the capabilities of the workmen at the time at which they were produced.

Of their efficiency it is difficult to speak, because the quality of the gunpowder which was used was no doubt greatly inferior to that of our own day. There is a cannon at Ehrenbreitstein of the date of 1529, about 18 inches in the bore, which is said to have required a charge of 94 lbs. of gunpowder, and to have thrown a ball weighing 180 lbs. It is quite clear, therefore, that, so far as the weight of these charges go, the productions of that period bear comparison with modern ordnance, and, making allowance for the limited facilities at their disposal, the men who first introduced such large cannon did marvels in the art of working iron.

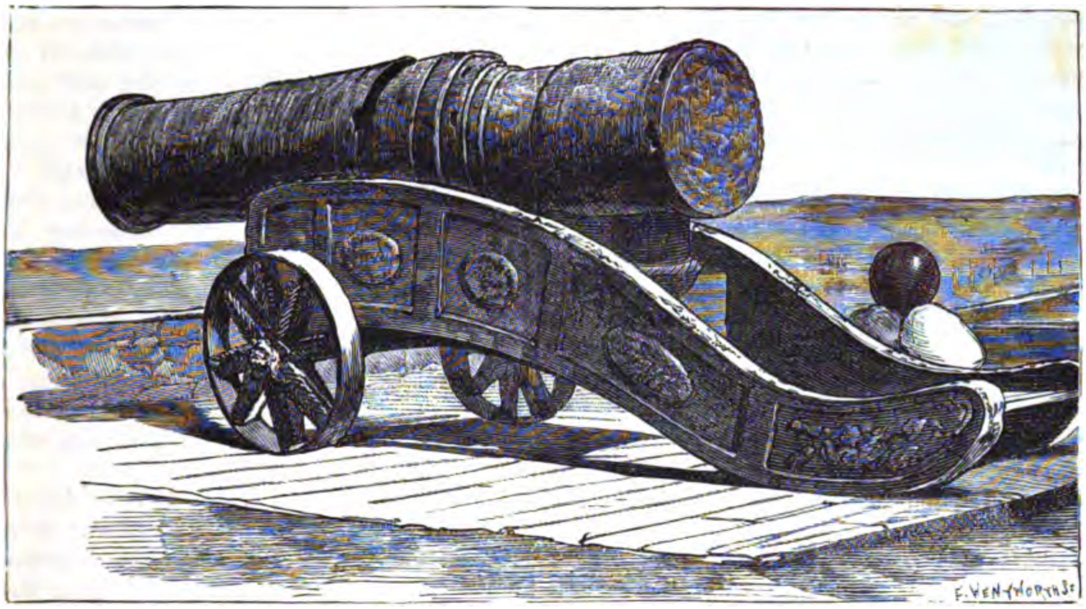
When we come to consider the safety of these cannon, there are few of our readers who would care to have been standing very near them when they were discharged. There are many records of the disastrous accidents which took place from the bursting of these monsters, whose size was far in excess of the skilled workmanship of the time. One of the best known of these mishaps was that which happened at the siege of Roxburgh Castle, when James II. of Scotland was killed. A fragment struck him on the thigh, and made a wound from which he soon bled to death. A long account is given by a contemporary chronicler of a somewhat similar accident which occurred in France, but, instead of the cannon bursting from a simple overcharge, it seems to have been blown to pieces in the act of being loaded the second time, as one-half of the previous charge appears to have hung fire. We owe our present Arsenal at Woolwich to an accident that occurred in more recent times. The Government had a gun-foundry in Moorfields, where, upon one occasion, in the year 1716, a distinguished party were gathered together to witness the operation of casting a large cannon. A young foreigner, named Schalch, who seems to have been almost an entire stranger, but who was well acquainted with the details of casting, noticed that one of the moulds had been insufficiently dried, and warned the moulders against using it. They disregarded his advice, and when he saw that he could not prevail upon them to desist, he immediately put himself well out of harm's way before the cannon was cast. A terrible explosion occurred when the molten metal rushed into the wet mould, owing to the sudden generation of steam that could find no outlet, and several persons were killed and a large number injured. It is said that search was then made for the man whose predictions had been so painfully verified, and that the Government employed him to advise about the best mode of preventing such accidents in future. The result was that Moorfields was given up as a site of a gun-foundry altogether, and upon his advice the establishment was removed to the Warren at Woolwich.

This occurred in the first quarter of last century;

and it would seem that the choice of the new site was fixed upon, not only upon the general ground of its suitability, but also because the Government Laboratory, which had previously been situated at Greenwich, had been removed to Woolwich in 1695. It is difficult to realise the difference that is presented to the view of the river-voyager of one hundred years ago and that which now attracts the notice of the crowds who pass the Woolwich of to-day. A few low and insignificant buildings, breaking with their ugly outline the monotony of the low-lying river-banks, was all that existed in the early days of the establishment. Even the name, so lately as the beginning of this century, suggests nothing of the modern Arsenal. It was called "Tower Place," or "King's Warren." As Woolwich has become the centre of the very important industry of the making of big guns, we shall have more to say elsewhere of what goes on there.

Meanwhile, referring to the industrial aspect of the subject in relation to our own country, if the reader will turn to the third chapter in this series, that on Fuel (Vol. I., pp. 75–9), he will readily understand how all the branches of the art of iron-working are dependent upon the acquisitions of succeeding generations, both with regard to the materials and the appliances available for converting them to specific uses. The connection between ordnance and the various changes that have occurred in the history of the iron trade has been uninterrupted. Before the art of casting had reached sufficient perfection to justify its being employed in the making of cannon, we find that the protracted labour of the blacksmith was the only means of obtaining ordnance strong enough to withstand the strain of exploding gunpowder. Thus the early history of the subject in England is invariably associated with improvements in the manufacture of malleable iron. In the fifteenth century, however, there were no steam-hammers to weld great masses of heated "scrap" into homogeneous lumps, and so we find that, although malleable iron has since proved to be the best of all material for the making of heavy ordnance, its application in those early times was so beset with difficulties that the alternative of cast-iron was eagerly resorted to as soon as it offered a prospect of being a reliable substitute. The manner in which the early cannon were constructed, by building together longitudinal strips of wrought iron and binding them together like the staves of a barrel, must, no doubt, have given employment to an immense number of workmen where the manufacture was carried on upon an extensive scale, but for this we must look rather to the Continent, and especially to France, where a national arsenal existed long before such an establishment was contemplated in England. No doubt, in the dockyards many large cannon were constructed, but in the main it appears that our armies and navies were dependent for many centuries upon private enterprise for the supply of their artillery. The continual demand for large weapons of destruction acted as a stimulus upon the iron-masters of those days, and added considerably to the importance of the iron industry in the small centres to which it was confined. Wherever these *composite* cannon were obtained it seems that cast-iron ordnance soon took their place. In the first volume we have already referred to the doings of a certain Peter Baude, a naturalised Frenchman, who seems to have been the Bessemer of the sixteenth century. He had a foundry in Sussex, and after doing much to advance the art of casting cannon, his mantle seems to have fallen upon his covenant servant, John Johnson, whose son Thomas was living at the time at which the old chronicler Stowe was writing. He informs us that in 1595 "he made forty-two cast pieces of ordnance of iron for the Earl of Cumberland, demy cannons, weighing three tons the piece." The same authority states that John Owen was the first man in England who cast brass ordnance, and the date he attributes to the occurrence is 1535. Peter Baude, who seems to have been the greatest master of the subject of iron-founding in that century, produced "hollow shot of cast iron, to be stuffed with firework or wild fire, whereof the bigger sort had screws of iron to receive a match to carry fire kindled, that the firework might be set on fire, for to break in small pieces the same hollow shot." Here we have the invention of explosive shells; and it is well that some improvements in the art of making mortars had been introduced, as otherwise the list of accidents already referred to would, no doubt, have been considerably lengthened. The naturalised Frenchman must have been courageous as well as ingenious, for it is recorded that while "King Henry was minding wars with France he was casting mortars of a calibre of from eleven to nineteen inches."

No doubt the Governments of the day were very glad to avail themselves of any private enterprise that would supply them with improved or cheaper ordnance, but there is little or no record of where it was obtained. At Carron, in Scotland, an early seat of the casting trade, the partners of that well-



Mons Meg.

known foundry acquired a great reputation, and supplied the nation with so much ordnance that the cannon in the making of which they so greatly excelled acquired the name of carronades. The peculiarity in the original guns of this description was that instead of working upon trunnions they were turned upon a swivel, that rendered them peculiarly adapted to the naval warfare in which they were employed.

With the explosion at Moorfields and the establishment of an arsenal at Woolwich, the industry that had previously been scattered over the country became gradually concentrated. Every year some new invention attracted the attention of the authorities, and rendered it more and more necessary that some great central department should assume the control of the entire subject, and so a constant accession of work ensued. *Demi-culverins, Mynions, Petards, Howitzers, Carronades,* all went out of date or fashion, and new engines of destruction took their place. The inventions of recent years are familiar to every one. Napoleon I., improving upon the labours of the greatest artillery officer of his time, General Gribeauval, startled Europe with the effectiveness of his field-batteries, and roused this country to fresh exertions. The names of Congreve and Shrapnel are associated with improvements in the first ten years of the present century, which were shortly followed by a host of others, and the necessity of keeping pace with other nations soon led the making of big guns to assume the position of a great industry.

FOREIGN RIVALRIES.—IX.

HARDWARE.

By H. R. Fox Bourne.

ENGLAND has always been famous for its hardware; and the multitude of trades included under that somewhat vague term—nearly every one of them of great value and importance when looked at separately—have in the aggregate contributed very largely to our national prosperity. We have come to regard it as our prerogative to make not only cotton, woollen, and other articles of clothing for all the world, but also knives, scissors, axes, and saws, pins, needles, nails, and screws, pots and pans, fenders and fire-irons, and all sorts of other metal goods, from swords and firearms to watches and clocks. If we are losing our reputation for pre-eminence in all such work, we are losing a

great deal; and no one can deny that there is, to say the least, some danger of that. Perhaps the evidence that will be given in the next few paragraphs goes to prove that, as regards a few, if not many of the trades, there is more than danger ahead of us.

So it would seem to be even in the case of cutlery, in the manufacture of which England, and especially the old capital of Hallamshire, has taken the lead for several centuries. The "Shefeld thwytel," or whittle, that Chaucer praised, was, it is true, only a clumsy blade of bar-steel, roughly fastened into a handle of wood or horn; but it was the best that could be got in those days, and Sheffield kept pace with all the improvements that were from time to time introduced. It claims the honour of having produced the first "jack-knife," in which was adopted the brilliant idea of shutting the blade into a groove in the handle with a spring; and when Queen Elizabeth gave shelter to the Protestant fugitives from the Netherlands, it profited by all the skill they brought with them. Until a few years ago, it was unrivalled for every kind of cutlery, and it still produces more durable and more carefully finished workmanship than can easily be obtained from any foreign centre of the trade. Yet it is allowing more than one foreign centre to surpass it in everything but the choicest specimens of its craft; and even in those to offer dangerous competition, by help of lower prices and greater variety in design. The notorious recklessness of the trades-unionists in holding out for their supposed rights is one, though not the only cause of this. "It is in a great measure attributable to the action of the men," says a competent authority, by no means prejudiced against the working classes, "that the trade has not developed much more rapidly and widely than it has. They are paid by 'piece,' and demand extra remuneration for everything that can be termed 'extra' in a knife, altogether irrespective of the time that it may take to make it. The misfortune appears to be that the rate of wages is far too low, and they endeavour to recoup themselves for this by charging all that they possibly can for 'extras.' A manufacturer may devote much time and thought to the bringing out of a new pattern, simple in its details, and easily made. It may have more 'extras,' but will not occupy so much time in making as one that has fewer. The men look only at the 'extras,' and ask such a price for making it as compels the manufacturer to abandon the idea of bringing it out, and it is therefore thrown aside. The men lose good work, and the manufacturer is discouraged in his efforts to improve and extend the trade, as he is unable to tempt business by offering new pattern goods on reasonable terms." Thereby, American, German, and other cutlers have been greatly assisted in their competition, and, though some Sheffield firms are able to face all opposition, their less eminent neighbours find themselves hard pressed, ever in the English market, by dealers in foreign manufactures. They suffer, too, from the prejudice against machinery, which many of them share with their men. That hand-work produces the daintiest results is likely enough; but the saving of expense attained by the use of steam-power far more than compensates for any benefit thus secured.

That is the case with axes and other edge-tools even more than with knives and scissors. It may be that the necessity of obtaining an instrument especially suitable for felling their huge forest trees first stimulated the inventive energy of the Americans; but certain it is that their axes are now unsurpassed, and have not only monopolised in their own country and in Canada the trade which was formerly a source of great profit to England, but are even used extensively by our own people and our customers in other parts of the world. In the making of saws and planes, again, we are being superseded by the Americans. While our Sheffield manufacturers have adopted no important variations in the shape and finish of these tools during the past half-century, the leading firms in the United States have developed scores of inventions. The preference of English carpenters for the broad, flat saw, with a handle at the end, over the thin steel band, stretched between two points, which is especially favoured by Frenchmen and Chinamen, may be a reason for not offering the latter in the home markets; but it is foolish to neglect the opportunity of providing foreign customers with the sort of tool they like best. They have allowed American manufacturers—one firm of whom, in Philadelphia, employs more than 1,200 hands in working up Sheffield steel into better saws than Sheffield cares to make—to appropriate nearly all this trade. So, too, with planes. "The planes manufactured in Great Britain and in other countries fifty years ago," said Mr. David M'Hardy, in his official report on the edge-tools and similar articles in the Philadelphia Exhibition of 1876, "were formed of best beech-wood. The plane-irons were of steel and iron welded together. The jointer-plane, about

twenty-one inches long, was a bulky tool, and the jack and hand planes were of the same materials. Very little change has been made upon the plane in Great Britain, unless in the superior workmanship and the higher quality of the plane-iron. American planes have now found their way into Great Britain, and it will be seen whether a fair trial is to be granted to the manufacturers of the New World. The American plane is constructed with a skeleton iron body, having a curved wooden handle. The plane-iron is of the finest cast steel. The cover is fitted with an ingenious trigger at the top, which, with a screw below the iron, admits of the plane being removed for sharpening and setting without the aid of the hammer, and with the greatest ease. The extensive varieties of plane-iron in use are fitted for every requirement. A very ingenious arrangement is applied to the tools for planing the insides of circles or other curved works, such as stair-rails, &c. The sole of the plane is formed of a plate of tempered steel about the thickness of a hand-saw, according to the length required, and this plate is adapted to the curve, and is securely fixed at each end. With this tool the work is done, not only better but in less time than formerly." With less waste of material, and all the economy that can be secured by the use of appropriate machinery, America now produces cheaper and better tools of this description than England, and consequently the world is, of course, learning to buy from America instead of from England as heretofore.

A notable instance of the way in which individuals may enrich themselves and benefit the trade of the whole nation by the prompt use of new ideas upon apparently trivial subjects, is furnished by the change in the manufacture of screws, as convenient substitutes, in many branches of carpenters' work, for the old-fashioned nails. It was a German clock-maker, named Colbert, who devised a plan for twisting iron wire into screws, instead of forging them. In 1798, the largest screw-making firm in England—that of Shorthouse, Wood, and Co., of Burton-on-Trent—was thought to be doing wonders in turning out 1,200 gross of screws weekly, by the help of fifty-nine pairs of hands, on the old system. In 1873, Messrs. Nettlefold and Chamberlain, of Birmingham, having adopted the new method, at the instigation, it is said, of the energetic member of Parliament for the town to whose industrial prosperity, as well as political renown, he has so largely contributed, but who has now retired from the firm, produced 150,000 gross every week, or upwards of 1,000,000,000 screws in the year. In so doing, however, they only followed the example of American manufacturers, and took from them a share of the profits that were to be obtained by the new way of making screws.

It would be greatly to the advantage of England if it had many more such enterprising firms. As it is, the Americans are, almost without opposition, driving us out of the field in the production of a great variety of the small but very necessary articles in use among carpenters and builders. The Hon. James Bain, then Lord Provost of Glasgow, reporting to our Government on the building hardware shown in the Philadelphia Exhibition, called attention to the wonderful progress made in these respects by our Transatlantic cousins, who put artistic finish even into their stair-rods, while at the same time rendering them cheaper and more durable, by coating them with nickel. "I think," he said, "our manufacturers should specially interest themselves in the action taken by the Americans in the use of this metal. The iron-mongery of a building—door-knobs, hinges, and suchlike—which with us is mostly of brass or iron, is by them usually coated with nickel. Their stove-fronts, door-plates, and other articles, which we usually make of polished iron or steel, are also coated with nickel, and varnished over with a solution of shellac in methylated spirits, which preserves them from oxidation and enables them to be kept clean and bright with little trouble."

When good work abounds, spurious imitations of it are sure to be plentiful; but the old effort to discredit all the numberless productions of Birmingham, by calling them "Brummagem goods," was not more unjust and foolish than is the more recent habit of condemning as trumpery all the ingenious novelties introduced by American manufacturers. Instead of sneering at them, English manufacturers, if they are wise, will follow the example of the Americans. By their inventive wit, and their mechanical tact, they are superseding us, for instance, in the lock trade. They will turn out a serviceable lock and key which they can afford to sell for two or three cents, or we can buy from them another which is cheap at a thousand dollars. A curious specimen of the latter sort is the chronometric lock, the history of which may be given in Mr. Bain's words:—"The thief-proof safes of the United States," he says, "are, I believe, admittedly superior in quality to those manufactured in Europe; and, when burglars effected an entrance into a bank, they found they could not drill the safe in the time

at their disposal; so they adopted a different mode of robbery. The gang seized and gagged the whole household. They then presented a pistol at the head of the manager and demanded the keys of the safe; and, as generally man will do anything to save his life, they got the keys, plundered the safe, locked it again, and made off, leaving the family gagged. Many burglaries of this kind have occurred in the United States. To prevent such a case happening, the chronometric lock has been invented. It is a mixture of a lock and a timepiece, and may also be a combination lock. Suppose the hour of closing the bank is five o'clock in the afternoon, and ten o'clock next morning that for opening it: the manager, when he goes to close the safe, sets the clock-work of the lock to ten o'clock next morning, and then locks the door of the safe. That done, it is impossible for any one to unlock the door till next day. The key is of no use till the usual hour for opening the bank, when the chronometric arrangement in the lock drops a bolt and permits the key to turn and the door to be opened." That particular lock is, perhaps, more ingenious than generally useful; but it illustrates the smartness with which the Americans contrive to meet every want, and threaten to render obsolete the older arrangements with which our own manufacturers think we ought to be satisfied because they were good enough for our forefathers.

Ingenuity and the extensive use of machinery are the chief means by which, as regards other things besides locks, the Americans are driving us out of our markets. In other countries the cheapness of labour serves the same purpose. England suffers under the double disadvantage of rejecting new mechanical devices, and having to pay dearly for its handicraft and its material. Our lock trade especially, of which Wolverhampton is the centre, is carried on principally by small manufacturers, or "master men," who, having no capital, and only a few hands apiece, have to pay a heavy tax to the middle-men who supply them with the metal which they work up, and another heavy tax to the other middle-men who take their goods to the market, while they have to divide nearly all their scanty profits among their dissatisfied assistants. These are antiquated conditions of trade, alike injurious to the masters and to the men.

In agricultural tools and machines, England has made great improvements during recent years; but its progress has not kept pace with that of the United States and Canada, where the requirements of the huge tracts of country to be dealt with have led to the manufacture of all sorts of appliances for saving time and labour, many of which are found as convenient in the Old World as in the New. American spades, shovels, hayforks, and similar articles are now brought even to England, where for lightness and durability, as well as cheapness, they are found superior to our own manufactures; and, if the larger and more complicated instruments do not often find their way across the Atlantic, there is no need of protective duties to keep English goods of this description out of the hands of the American farmers. They have good reason to prefer the articles made at their own doors, and those articles are steadily being exported to countries for which England was formerly almost the only caterer.

That is true of a score of other varieties of hardware, as well as of agricultural implements. Sewing-machines may be mentioned in passing as an illustration of the way in which American inventors are tempting the people of other countries to give up their time-honoured habits and take to new devices which, besides all the other advantages that come from them, bring profit to their producers. Machine-made clocks and watches furnish another. England has long held its own, though not without some damage, against the rivalry of Switzerland. Both England and Switzerland, however, have now to face the more formidable opposition coming from America. The appliances for watch-making by machinery are still very crude, and, however they may be perfected, hand-work will doubtless always have its advantages for those who can afford to pay high prices. But it will be small satisfaction to England if it continues to manufacture a few costly ornaments for millionaires, while the United States supply the millions with cheap articles sufficient to their needs.

Looking generally to the prospects of our hardware trades, there can be no doubt that the closest competition we have to be prepared for will come from the United States. England, however, has not one or two rivals only, but many to face. Each country is learning to make tools for itself, and the things made with tools; and in some, where this would be least expected, like Russia, the lesson is being learnt very quickly indeed. The staunchest free-trader must admit that as regards manufactures like these, protection, to some extent, meets the intentions of its advocates. By virtually prohibiting the importation into any district of implements

that it cannot do without, those in immediate need of them suffer greatly, but local enterprise is inevitably stimulated, and the district is forced into the habit of producing the implements as best it can, and thus gets into the way of producing good ones. If England can persuade the rest of the world to abandon the protectionist heresies which appear to be now spreading instead of declining, it can never hope to persuade its former customers to resume their dealings with it in commodities which they have acquired the art of making more conveniently at home. Its only chance of getting back its trade is in showing that its produce is better than the local produce, and better, too, than any other country can supply. What will be its case if it is found that some other country has superseded it in mechanical skill, and is quite prepared to cater, as it once did, for the rest of the world?

That risk is imminent, and our best prospect of averting the catastrophe is in opening our eyes to it. It would be tedious here to multiply the illustrations that have been given of the mechanical victories that America is gaining over us; but few can have failed to notice how many and various are the cunning and successful novelties in domestic articles of all sorts which are constantly being introduced from the United States, though they may not be aware how extensive is the trade which that country is developing with our former customers in other lands. The secret is to be found especially in the wonderful intelligence displayed by its inventors, and in the wonderful semblance of intelligence which they impart both to the implements which they construct, and yet more to the machines by which those implements are constructed. This was a notable feature in the great period of English inventions, one or two generations ago. France and other countries have given startling but more spasmodic evidence of it. It is now found especially among our American cousins. They have set their wits to work to find out and perfect all sorts of devices for economising labour and expense, both in the production of tools and machines, and in the use of the machines and tools produced; and the success they have thus far achieved seems to be only the beginning of the work they mean to do. "In past times," says Mr. John Anderson, C.E., "England has been the nursery-ground of the manufacturing system. Her factories have been visited, and her systems of cotton and other textile manufactures have been copied by all nations; but the time seems to have arrived when we shall have to visit America in the same way, and for the same purpose, in regard to the production of other things; and there is no time to be lost if we mean to hold our own in the hardware trade of the world, at least in regard to the class of things that are required in large number or quantity. Great Britain certainly can claim the credit of having been the birthplace of modern machine tools, and has done wonders in raising the mechanical standard of perfection; and her influence for good in the advance of civilisation thereby, is incalculable. But when we consider the enormously greater area of the American continent, it is a matter of vast importance that tools have taken such a hold of the American mind, which will influence the civilisation of the Western world for ages to come, and will exercise a powerful effect, not only on the continent, but in Australia, China, and the world generally. This, therefore, has a profound significance which can be scarcely overrated. Britain and the United States are not on equal terms. By past exertion the former has become rich; the latter is still comparatively poor, but with an abundance of brain-power in active exercise. America is in much the same condition as was Great Britain about half a century ago. In this competition of tool-devising, brains count for more than wealth, and will gain an advantage." Those words, and the undeniable truth contained in them, are well worth heeding. If the world is to be the better for it, it may be right that America should take the place in commerce and manufactures hitherto held by England; but it will be still better for the world, as well as for England herself, that she should not meekly allow herself to be beaten in the race in which she has so long been foremost.

COTTON.—XX.

LACE BLEACHING, DRESSING, ETC.—THE HOSIERY TRADE—LUDDISM.

BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

THE bleaching and dressing of lace are operations generally carried on as a separate branch of business. Owing to the delicate and open nature of the fabric it must be handled tenderly, and on no account be wrung or twisted. It is bleached with alkaline lyes and the superfluous moisture is removed by a centrifugal drying-machine. This machine consists of a cylindrical vessel of wire gauze which is made to revolve at a high speed. The lace is placed in the cylinder, and as the latter revolves the water is driven off by centrifugal force and escapes through the gauze, leaving the lace perfectly dry in the course of a few minutes. In order to preserve the beauty of the design, and the equality of the meshes, it is desirable in dressing the lace to handle it as little as possible. The dresser receives the lace after it has been bleached, dyed, or purified, and begins operations by passing it through a hot mixture of gum and starch with other materials. The superfluous fluid is in this case removed by squeezing the fabric between wooden rollers. From this department the lace is removed to the stretching-room, which is usually of great length, and the windows of which are very large and close together, as not only is a good light required, but also free ventilation. Usually there are in each room two frames which extend parallel to each other from end to end of the apartment. Each frame consists of two rails placed at a convenient height. On the upper edge of each rail is a row of upright pins, and by means of a winch arrangement one rail may be made to approach to or recede from the other, and so be adjusted to the width of the lace to be dealt with. The selvedges of each piece of lace are run on to the pins by girls, who acquire great expertness in executing the work. When the entire web is fixed in this way a turn or two of the winch-handle stretches it both sidewise and lengthwise, and opens up all the meshes. Care has to be taken not to disturb the outline of the latter, as on their regularity the value of the lace largely depends. Strict attention has also to be paid to the amount of "dress" in regard to stiffness and weight, and as to colour, clearness, crispness, and elasticity—on which particulars, together with the peculiar ingredients used, has depended the preference given to French over English dressed lace.

Owing to the glutinous nature of the dressing it has a tendency to form films over the meshes, especially when the latter are of small size, and also to clog the heavier parts of the fabric. To prevent this the lace is rubbed gently with fine flannel cloths, and beaten during distension with light switches which cause it to vibrate and jerk off the superfluous dressing. In order to dry the lace as speedily as possible, the stretching-room is kept at a high temperature, and when the stretching, switching, &c., are completed, desiccation is promoted by the use of fans. When the web on one frame is advanced to this point it is left to stiffen, and a web is put on the second frame and similarly treated. The first web is then removed from the frame, and carefully rolled up, and so on; the staff of workers in the room being just sufficient to keep the two frames going. Nets intended for the foundations of bonnets, &c., are heavily loaded with size. A piece which in the undressed state weighs only 15lbs., will, when dressed in what is called the Paris way, have its weight increased four-fold. As an instance of how changes of fashion sometimes seriously affect particular branches of trade, it may be mentioned that one firm largely engaged in dressing stiffening-nets found their receipts drop off by many thousands a year when ladies resolved to abolish bonnet curtains.

Plain bobbin-net, when it leaves the stretching-room, is cut into convenient widths for sale; but webs of narrow laces have other processes to go through. As already stated, the lace-machine weaves a number of widths of narrow lace at a time, and these for convenience of manipulation are laced together at the edges, so as to form a web as wide as the machine. When webs of this kind have been bleached and dressed they are handed over to the menders, whose business it is to examine minutely every part of the fabric, and repair all broken threads or other defects. The menders have consequently to have sharp eyes and to be very expert in using the needle. It is surprising to see how neatly and expeditiously they effect repairs. They occupy a well-lighted room, and when dealing with white lace wear black or blue aprons, against which the texture of the web is sharply defined, and blemishes may be readily detected. When mending black lace white aprons are used to secure the same end. The menders sit on low stools, and

to examine the lace draw it over their knees. From the menders the lace passes to the "drawers," whose business it is to pick out the lacing threads and separate the web into widths of edging or insertion. These widths are, in the case of scalloped or vandyked edging, taken charge of by the "clippers," who clip round the shaped edge and remove the superfluous material. In some cases another set of workers are called into requisition. These are the "purlers," who attach a fine edge to the lace. This done, the lace is ready to be measured, cut into lengths, and wound upon cards for sale.

A glance at the pattern books of any leading Nottingham firm will show a marvellous variety of designs, among which, while there is much that will excite admiration, there is little to complain of from an artistic point of view. Our home manufacturers had a stiff battle to fight in competition with their French rivals; but they took the right way to achieve success when they gave attention to the training of designers for themselves and aided the establishment of schools of art.

Hosiery is made from cotton, silk, and various kinds of wool. The first of these fibres is so largely used that it is necessary to give some account here of that branch of manufacture. The invention of the stocking-frame and the improvements effected upon it have been dealt with elsewhere in this work, and require no detailed notice here; nor need we trace minutely the vicissitudes through which the hosiery trade has passed, as that has been so admirably done in Mr. Felkin's "History of the Hosiery and Lace Manufactures." The first yarns spun by machinery were, as we have seen, disposed of to the hosiery makers, who esteemed it on account of its firmness compared with what was spun by hand. So early as the year 1787 the quantity of cotton yarn annually converted into hosiery was 1,500,000lbs. In 1812 there were employed in the cotton hosiery trade of England 10,919 frames, of which 7,589 were engaged on plain hose, 350 on gauze, 250 on pieces, 350 on gloves, 530 on drawers and shirts, 550 on sandals and socks, 750 on ribbed hose, 200 on plain caps, and 350 on spider hose. Twenty-one years later 10,300 frames were engaged on "fashioned" cotton goods and 6,000 on "cut-ups." The former worked up £73,000 worth of material, and the value of the goods made was £325,000; and the latter £172,000 worth of material, which yielded a return of £555,000. The workers employed on "cut-ups" earned from 10s. to 24s. per week, and the others from 4s. to 7s.

The workpeople engaged in the hosiery trade suffered severely from various causes for many years. The business was carried on upon a most unsatisfactory system, and was peculiarly liable to fluctuations. Referring to the hard times of the trade Mr. Felkin says:—"We do not hesitate to affirm that the actual sufferings and privations experienced during the so-called Lancashire famine of 1863-6, were far less than the distress in the midland hosiery district during the interval between 1810 and 1845, when it became a long and widely-spread practice to still the cravings of hunger in the adult by opium taken in the solid form, and by children in that of Godfrey's cordial. These people had been for years at the lowest point of existence, feeding on bread and potatoes sometimes for weeks together. Their furniture gradually disappeared; their clothing could scarcely be held together; and nothing new had been obtained by many families for so long that they could not remember the time. Their dwellings were for the most part filthy and the abodes of discontent and misery. The children had no scholastic education at all." The special causes of this state of matters were the parish apprentice system, the construction of needless frames by speculators for the sake of rent, middle-men, and payment of wages by truck.

Returns obtained in the year 1844 showed that there were then employed on cotton hosiery in Derbyshire 4,380 frames; in Nottinghamshire, 12,440; in Leicestershire, 6,933; and elsewhere, 1,070; making a grand total of 24,823 frames, on which raw material to the value of £163,000 was worked up. Wages and profits were reckoned at £835,700. Improved machines worked by steam or water began to be introduced about this time, and things took a decided turn for the better. The full benefit of this was, however, not enjoyed by the workpeople, who by combinations and strikes did much to hinder the development of business. A strike which took place in 1860 led to the establishment of a Board of Conciliation in the trade, the operation of which has been most beneficial. When difficulties have arisen they have as a rule been amicably settled, and such a thing as a strike is rarely if ever heard of. Under the settled mode of working, wages have increased, and, save, of course, the general depression of trade which has been experienced at intervals, there has been little to complain of either on the part of employers or employed.

The hosiery manufacture is almost exclusively concentrated in the counties of Nottingham,

Derby, and Leicester. There are several factories in Hawick, Dumfries, and one or two other towns in Scotland, and the trade is carried on to a small extent in the north of Ireland, notably at Balbriggan. The number of operatives employed in all the branches of the hosiery trade in 1866 was computed to be as follows:—42,000 working narrow frames, 8,000 at wide ones, and about 100,000 menders, seamers, winders, cutters, finishers, and makers up (chiefly women and children); total 150,000. The value of the goods produced was estimated at eight millions sterling. Since then the hosiery trade has shared the fortunes of other branches of textile industry; and one conspicuous feature of its later development has been the improved condition of the workpeople. We have been unable to obtain any separate and trustworthy statistics of the present extent of the cotton hosiery manufacture; but we may assume that it has grown considerably since the returns above quoted were obtained.

A dark chapter in the history of the machine-made lace and hosiery trades of England is that which relates to the breaking of machines by disaffected workmen, a crime which came to be designated Luddism, from Ludd, the name of one of the wreckers. This form of outrage appears to have originated in London, about the year 1710, when 100 machines belonging to a master stocking-maker named Nicholson and others were broken and thrown into the street, because their owners employed more apprentices than the journeymen thought desirable. The system of apprenticing by parish authorities was then in full swing, and it was considered an advantageous arrangement for the ratepayers and the masters to have boys transferred in this way. A premium of £5 was usually paid by the parish, and smart boys could soon be taught to do as much work as journeymen, so that there were strong inducements for masters to secure their services. It is obvious, however, that such a system must have acted most prejudicially against the boys when their term of apprenticeship expired, and they were cast adrift to find employment as they best could. Parliament was entreated to put a stop to the parish apprentice system; but in vain, and bands of idle men avenged themselves on employers in various parts of the country. In 1727 an Act was passed making the wilful destruction of machinery a capital offence. This had the effect of putting a stop to machine-breaking for a long time. In 1770 the silk weavers of Spitalfields became disaffected through the small price paid for their work, and night after night webs were destroyed in the looms. A number of the culprits were arrested and hanged in front of the houses in which the offences had been committed. Such a severe penalty could not fail to have the desired effect. But it was only for a time. Eight years later 300 stocking-frames, and other property belonging to hosiers in Nottingham were destroyed because their owners were instrumental in bringing about the rejection of bills in Parliament for the regulation of apprentices and prevention of fraudulent work. The house of one of the obnoxious employers was burned at the same time. Soon afterwards a newly-invented stocking-frame was taken out of the Exchange at Leicester by a mob, and destroyed in spite of the entreaties of the mayor and others. A firm of worsted yarn makers at Leicester adopted in 1788 improved machinery for spinning. Their enterprise gave offence, and not only was all the machinery in their factory destroyed, but their private houses were burned. The result was that a branch of industry calculated to be of immense benefit to the town was driven into other districts, where it flourished apace.

Trade became very dull in the year 1810, and finding their warehouses full of goods for which they could get no sale, manufacturers reduced their production, but gave their workpeople a choice of going on at a reduced wage. This the latter declined to accept, and soon thousands of them were idle and starving. In March, 1811, many of the unemployed congregated in Nottingham, and began to destroy the machines of all the masters who were paying reduced wages. They operated in several gangs, and carried on their depredations over a wide area. A strong military force was stationed in the district, but the Luddites observed great secrecy in their operations. A royal proclamation was issued, and large rewards were offered for information as to the depredators; but the work of destruction still went on. Many frames were broken, and farmers who served in the yeomanry, who had been called out to suppress the rioting, had their corn-stacks burnt.

The repressive Act of 1727 must have been repealed, or found ineffective, for in March, 1812, another law was passed making the breaking of a frame a capital offence. A few weeks afterwards a hosier in Nottingham who had made himself objectionable to the workpeople was shot while standing in his own door, and when winter came on, the breaking of machines was resumed, and

was continued at intervals for three or four years. In an attack made in October, 1814, on the house of a gentleman at Basford, who had secured the apprehension of a Luddite leader, two persons were shot. It was June, 1816, before another outbreak occurred. Then a shop at Nottingham was entered and nineteen frames were smashed; two men were arrested and tried for the offence, but they succeeded in proving an *alibi*. It came out afterwards that there were a number of armed men in court, who had been deputed, in the event of a conviction, to shoot both the judge and the jurymen. It was in the same month that the fine factory of Messrs. Heathcoat, Lacy, and Boden, at Loughborough, was attacked, and fifty-five frames, worth £10,000, utterly destroyed. An attempt was also made to shoot one of the workmen. For this offence a man named Towle, who had been the cause of the bloodshed at Basford in 1814, was convicted and hanged; and subsequently six of his companions shared a similar fate, while two were transported for life. Mr. Heathcoat and his partners sued the county for the loss they had sustained, and obtained in the Court of King's Bench a judgment in their favour for £10,000; a condition was attached that the money should be spent locally; but Mr. Heathcoat demurred to this, saying that his life had been threatened, and he would go as far off as possible from such desperate men. The consequence was that he did not receive the money, and soon afterwards Mr. Heathcoat, separating from his partners, went to Tiverton, and there established himself, as stated in a previous chapter.

NOTTINGHAM MARKET PLACE.

From first to last the Luddites destroyed about one thousand stocking-frames, and eighty lace frames, chiefly in Nottingham and its immediate neighbourhood. "The broad substratum," says Mr. Felkin, "of the whole of this wretched heap of wrong-doing was undoubtedly the hunger and misery into which the larger portion of the fifty

thousand frame-work-knitters and their families were fallen, and from which they never fully emerged for the following forty years. During that long interval, the average of the frame-work-knitters' clear earnings by long hours of labour did not exceed six shillings a week."

POTTERY AND PORCELAIN.—V.

IRON-STONE CHINA—TERRA-COTTA—ITS ANTIQUITY; ITS BEAUTY; ITS ORNAMENTATION.

By James Francis McCarthy.

IRON-STONE ware is that description of pottery which occupies an intermediate place between pure china on the one hand and ordinary earthenware on the other. Strictly speaking, it may be classed with the former. And it must be remembered that iron-stone ware has now been so much improved in its quality that it is as superior to ordinary earthenware as a piece of high-class Wedgwood jasper work is to a vase of inferior Parian. At the same time that stone ware is capable of and does receive the richest conventional decoration, with the fulness of colouring that can be given to china, it has, in addition, the advantage of being made of a very tenacious, durable, and hard clay; so that whatever choice ornamentation it may undergo is not, as with china ware, almost necessarily allied to a fragile body. As the manufacture of this stone ware—or, as it is now best known, "Mason's Patent Iron-stone China"—is by comparison of later origin, and is exclusively confined to one firm, a few facts concerning it may not be uninteresting.

Some seventy years ago, in 1813, Mr. Charles James Mason, a potter of great practical experience, pursued his business at a small manufactory at "Lane Delph" (now called Middle Fenton), near Stoke-upon-Trent. He was then in partnership with his brother, George Mill Mason, and the firm was known as "G. M. and C. J. Mason." In this same year Charles James Mason, who was not only a skilful potter, but possessed great taste, after many anxious and expensive experiments—such as all experiments for the development of pottery appear to be—at last reaped the reward of his perseverance. He discovered the method of making that particular kind of ware which now bears his name as its inventor, and of the nature of which we shall presently more fully treat. He took out a patent for the process. The ware became popular, not only by reason of its novelty, but because of its intrinsic excellence; and for many years its manufacture was attended with success and profit. Some time after 1832 Mr. George Mason retired from the business, which was then carried on by the patentee alone. But with this change there came another: that of business adversity. For many reasons, but more particularly owing to want of capital—without which even great inventions are impeded—trade dwindled. Crippled for want of sufficient resources, moulds, copper-plates, &c., which originally had cost considerable sums of money, passed into various hands as debt securities. In 1851, no longer able to cope with continued adversity, Mr. Charles Mason sold his patent, the moulds, copper-plates, and other stock, and in fact the entire business, to Mr. Francis Morley, who removed it from Fenton to Shelton, where he had succeeded to the works of Messrs. Hicks, Meigh, and Johnson. This manufactory is said to be one of the oldest in the Potteries, and has the credit of being the first to introduce the process of printing in oil. The two manufactories having been thus amalgamated, Mr. Morley, with much earnestness, and a corresponding degree of success, entered upon the production of ware according to the patented process of Mason. He revived its popularity; and at the first French Exhibition in 1856 was awarded the first class medal for an exhibition of iron-stone china, casually, and not specially, taken from the general stock.

About twenty years ago there is another episode in the somewhat eventful history of the manufacture of this ware. Mr. Francis Morley retired from business about that time, and the trade, together with the right of Mason's valuable patent and the entire working material, was sold to Messrs. Geo. L. Ashworth Brothers. In the very heart of the Potteries, at Hanley, and not far from the centre of that busy town, this firm now manufactures Mason's patent iron-stone china. Lying a little to the right of the main thoroughfare are Messrs. Ashworth's works. Stretching away on either side in square blocks of dark brick shopping, with many huge ovens looming over all, this manufactory covers

more than four acres of ground, and gives regular employment to as many as five hundred hands. The grinding processes are carried on at another works three miles away.

The precise proportions of the various substances which constitute the plastic clay for iron-stone ware, as well as the chemical ingredients, are known only to the members of the firm. As observed in passing through the "slip" house, the appearance of the soft clay is not materially different from that used for ordinary earthenware. In colour it is almost alike, but it is after the firing that the great dissimilarity in the nature of the ware is observable. Messrs. Ashworth Brothers manufacture every description of their patent kind of earthenware for table, toilet, dessert, and other services, as well as a variety of ornamental goods. Moreover, they make sanitary ware and insulators for our own and other Governments. The processes for the production of this description of ware are precisely similar to those which have been previously described, and of course need no repetition. It is of results that we have to speak. As iron-stone china ought to be specially adapted for hard service—for use in steamers and sailing vessels, in hospitals and public schools and hotels—it is obviously essential that it should have enduring properties: it must be hard, tenacious, tough, not easily broken. At the works under notice we have proof of how these qualities are all combined in the manufacture of this ware. After the first firing, it is noticeable that the ware in its "biscuit" and most brittle state is relatively hard and tough when contrasted with either china or the usual kind of earthenware in a similarly unadvanced condition. But it is when the enamelling has been applied that the highest degree of durability—almost reaching to indestructibility—is attained. The enamel of itself is of an exceptionally hard, unyielding nature, and being fused to a body of clay also peculiarly firm, necessarily produces a close, metallic kind of pottery. A dinner-plate made of iron-stone china may be sharply struck against hard substances many times, and not so much as "chip." Articles made specially strong may be dashed to the ground with no fear of breakage; and the proverbial destructiveness of the "bull in the china shop" would lose its significance should that animal, in a spirit of bovine anger, ever rush into a store of iron-stone ware.

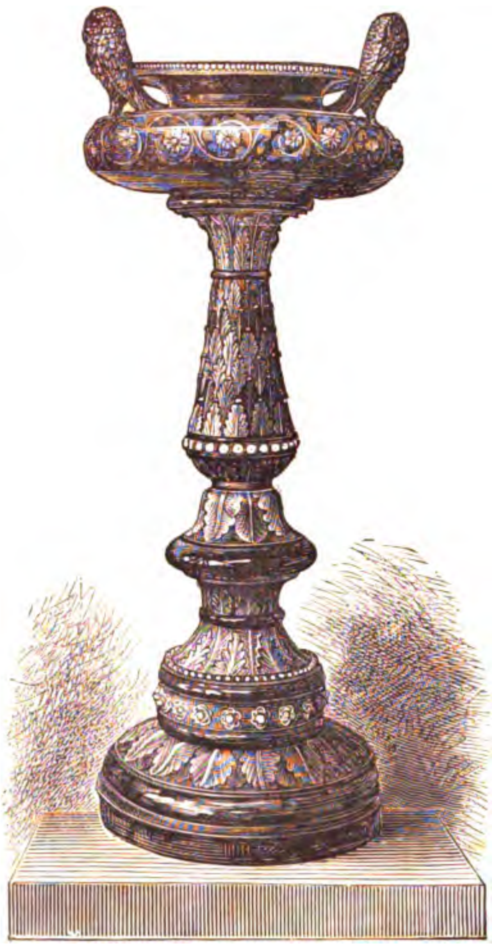
Now, while this ware is remarkably strong, it can be so produced as to approach china ware in appearance. It is made vitreous and at least semi-translucent, and then, as far as regards ornamentation, is capable of receiving rich treatment. Of decoration by means of the printing process a design of figures or flowers on a coloured ground is very effective. The article to be so decorated must undergo the "ground laying" process, which is that of affixing the colour on the body of the ware. With a fine-haired brush a coating of oil is applied, and with a piece of cotton-wool containing oxides the necessary colour is dusted on. In the subsequent process of burning, whilst the oil has disappeared the effect of the oxides has been to preserve the colour on the surface. Those parts of the surface which are to remain white, so that the pattern may be defined, have to be "stencilled." A mixture of rose-pink, sugar, and water, which constitutes the "stencil," is laid on, and protects that part of the surface which it covers from the colour. When the colour has been dried on, the "stencilling," through immersion in water, is to be cleared off. Table-ware, and particularly stone-ware jugs, ornamented by this process, with classical designs as the pattern, resting on a rich coral ground, with gold borderings, have a particularly chaste appearance. The figures are transferred by the printing process, and appear in black and white, except when they are "etched" in colours, which is somewhat rare. They must have been engraved on the plates, from which the transfer sheets are taken, in a firm, yet delicate manner, so clearly and softly do they appear, even after the firing. Thus, for instance, the central figures and familiar incidents of Homer's immortal epic, when they are artistically portrayed on the surface of clay, appeal to us with considerable realistic force, and may be said to give a sort of pictured life to the majestic grandeur of the poem. Dinner services in iron-stone china, for depth and richness of colouring, can be just as effectively treated as china. With the exception of designs of fruit, the decoration is principally conventional, Japanese and Oriental being the patterns nearly always chosen. But the colourings which these fantastic designs receive are rich beyond description, and this without being in any degree inharmonious, glaring, or untasteful. Usually interwoven with the colours is rich and heavy gilding, which is added after the colours and gives a touch of brightness to the decoration. Ware richly and profusely decorated as this is, has frequently to be fired four and even five times.

As to specimens of ornamental iron-stone ware, special mention, both for construction and ornamentation, may be made of the diamond-shaped vases grotesquely decorated with dragon-like forms

in various colours, and of Indian jars of large proportions, perfect as specimens of modelling in clay, and lavish in the richness of colouring. Messrs. Ashworth Brothers have not only been favoured with success flowing from the ordinary channels of trade, but have secured several Government contracts.

The manufacture of terra-cotta in this country was the revival of that branch of the potter's industry which instinctively recalls its classical antiquity. Thanks to the labours of the antiquary, we have been made familiar with evidences of the art when probably it was in its infancy. We know that after the lapse of thousands of years terra-cotta vases have been disentombed, not much impaired by time, and retaining their original artistic beauty, mellowed, if possible, by the flight of ages. When examining the finer specimens of Etruscan vases, it is apparent how perfectly they were fashioned. For symmetrical and graceful proportions, for elegance and purity of design, it would seem to be impossible for the hand of man ever to shape clay more absolutely true and beautiful. Indeed, the highest aspiration of the potter of this age, with all his mechanical aids, is to imitate, as closely as he can, this classical workmanship which, through the medium of a clay vase that has endured through long ages, perpetuates art in its pristine purity. The terra-cotta vases of the Romans are to-day the recognised models for imitation; and the more faithful the imitation the more precious is regarded the result.

In terra-cotta (which literally means burnt earth) may be made both useful and ornamental pottery. In these days it is principally used for the production of the latter. To Josiah Wedgwood, who by thought and action did so much to raise English pottery to a great industrial art, the credit is due of introducing into this country the manufacture of terra-cotta. This took place more than a hundred years ago; but the famous firm of which he was the founder have now practically discontinued the production of this kind of ware. In fact, throughout the whole of the Potteries the manufacture of terra-cotta is comparatively limited; although when specially ordered it can be made as excellently there as anywhere else. The principal terra-cotta works are those of the Torquay Terra-cotta Company and the Watcomb Terra-cotta Company.


JARDINIÈRE IN DOULTON WARE.

A visit, however, to the Brownhills Pottery Company, Tunstall, affords an opportunity of seeing the manufacture of terra-cotta ware and some excellent finished specimens of this kind of work. In the plastic clay which serves the purpose of producing terra-cotta, the finest red marl, obtained in the neighbourhood, forms the chief element. This, when mixed with a small proportion of ground stone, is blended into "slip," and finally, when it has passed through many sieves, constitutes a fine plastic clay. In its nature it is weaker and more porous than the clay used for earthen and china ware. To the latter fact is attributable, as may have been frequently noticed, the coolness of articles made in terra-cotta. Of the operations, manipulative and mechanical, connected with it, that of "throwing" is used in making jugs, small and sometimes large fancy vases, teapots, and fancy circular ornaments, when the outlines are not too elaborate to render this operation impossible. For the heavier and more ornamental class of terra-cotta, the "moulding" and "casting" processes are necessary. For

example, moulding would be used for constructing large vases, when they are, as is often the case, several feet high, such as jardinières, ewers, figures, fancy articles of unusual dimensions, like large scent jars, flower-pots, &c. The process of moulding as it is employed in fashioning similar articles in the ordinary kinds of plastic clay, and which has already been described, is precisely the same when connected with terra-cotta. There is, however, this difference, which is one of workmanship: the clay for terra-cotta purposes is more difficult to work by the moulder, and therefore he gets more wages for his labour. "Casting" is always needed in fashioning statuary articles—of which great quantities are made in terra-cotta—and that class of ornamental pottery which the moulding process cannot effect. As in the case of "moulding," a model of any required pattern is traced out in plaster of Paris, and from it a mould is taken. When there are more moulds than one, they are united in a firmly-bound stone casing; through a hole at the top of this casing, "slip" or liquid clay is poured. It runs round the outlines of the mould, upon which, when they have completely absorbed the slip, it is allowed to dry. When this takes place, which is in the course of half an hour, some more liquid clay is poured in, and that when dry, increases the thickness of the clay. As a rule, when the liquid clay has been poured in for the third time, a sufficient thickness—namely, about a quarter of an inch—has been formed. When the clay has dried until it becomes somewhat hard, it is separated from the mould; of course, by this process the article is quite hollow. In many cases—when, for instance, figures difficult in detailed outline have to be cast—the process must be done by separate sets of "casts," which, when properly fitted together, form the required pattern. In its "green" state — that is, while it is solidifying for the first firing—ware made by this or the "moulding" method has to be very delicately handled; and when placed in the "biscuit" ovens the nicest

VASE. (*Brownhills Pottery Company.*)

precautions for its safety and well-regulated firing have to be observed. This first firing lasts about forty-eight hours, and assuming they have safely withstood this test and come out unblemished, the terra-cotta articles are fit to undergo subsequent processes.

A large quantity of terra-cotta which is used for domestic purposes is quite plain, and free from even the simplest kinds of ornamentation. This description is glazed internally, while those articles which receive external decoration are not inwardly glazed. The "glaze" which is used for jugs and ware of that nature consists of the same constituent chemical and mineral properties as that used in earthenware. But there is one description of "glaze" which is peculiar to terra-cotta articles: it is that which gives a deep jet-black surface to the original red body of the ware, and is chiefly seen on terra-cotta teapots and on articles in which ornamentation needs to be thrown up in striking relief on a dark ground. In its liquid state this "glaze" is of a grey colour, but when burnt in the "glost" oven for about twenty-four hours it is turned into jet black. The red clay has conduced to this effect: just as, on the other hand, the same kind of enamel if applied to and burnt on white ware would have been of a beautiful mazarin blue. When the "glaze" has been applied, whatever ornamentation is required is generally effected by the aid of painting in different colours by raised enamels, "etching" in colours, and gilding. As an example of pleasing ornamentation, that which some of the superior and large-sized vases receive may be briefly noted. On the jet-black enamel the pattern is outlined by the "printing" process previously described. The decoration we can faintly see foreshadowed; it will consist, as the central ornamentation, of birds of passage, with a bordering of flowers and foliage, with turquoise beading surmounting the whole. The birds will appear in gilt relief,

TWO HANDED VASE. (*Brownhills Pottery Company.*)

while the flowers, the leaves, and the turquoise band are to be similarly treated in colours. The effect is arrived at after the following stages:—To the decorative room, which is principally occupied by female etchers, the vase is passed. One of the etchers takes her painting brush, and over the outlines of the birds places a thin coating of paste; then on this she delicately puts the gold, which is mixed with oil. The various colours for the flowers and foliage are mixed with white enamel, otherwise it would be impossible to obtain the desired relief. These colours are traced on with a brush, while the turquoise, the only colour which without any mixture with enamel will stand sharply defined against the surface, is also applied. After being burnt in the "glost" oven for about sixteen hours the effect is realised. When scoured, the gold is rubbed with a blood stone; and then the birds, perfectly drawn, glisten in their plumage of gold; the flowers and the leaves appear with the freshness and the reality of nature; the turquoise beading is exactly like the precious stones it so faithfully imitates. The colours have a rich and soft appearance, and the blending of them has been so perfect as to create the loveliest harmony of tints. There is another kind of ornamentation which has an equally chaste effect—the painting in white raised enamels of figures, flowers, and leaves. When tinted in varying shades of colour we have a pleasant picture on clay. This kind of ornamentation, particularly with white enamels, with a slight bordering of gold, is applied to little fancy knick-knacks which have not been glazed in the manner previously mentioned. The richest kind of decoration on the unenamelled body of terra-cotta is generally seen on the large and superior vases.

HEMP, FLAX, AND JUTE.—XX.

THE BRITISH LINEN COMPANY—PROGRESS OF THE SCOTTISH LINEN TRADE.

By David Bremner, Author of "The Industries of Scotland."

In the year 1746 the British Linen Company was founded at Edinburgh by royal charter. Postlethwayte, in his "Dictionary of Commerce," published in 1766, gives the following account of the origin of the company:—"His Grace the Duke of Argyll and other lords and gentlemen, finding some difficulties to attend the spinners of flax into yarn, as well as the weaving of the said yarn into different sorts of linen, by reason of the want of a ready sale for their goods, and they being made to keep them on hand for a market, were often obliged to sell them at an under value, to the great prejudice of the manufacture. On these considerations they were incorporated by a charter, from his Majesty, under the name of the British Linen Company, with a capital of £100,000, for trading in all branches of this manufacture. They import flax from abroad, linseed, pot and wood ashes for bleaching, and sell them on credit to proper hands, then buy the yarn and linen, all at reasonable prices; which linen, particularly the sort corresponding to Osnaburgs, &c., fit for America and the West Indies, they keep in large warehouses both here and at London, where they are sold for exportation." The operations of the company had the desired effect of stimulating the growth of the linen manufacture; but after a time its mode of operation was altered, and it became a banking firm. Dealing in yarns and linens was abandoned, the capital of the company increased to a million sterling, and business was confined to advancing money to the manufacturers and merchants. As a banking concern the company still exists, and it has had a prosperous career.

In Bowen's "History of the University of Edinburgh," it is stated that between the years 1750 and 1760 a great degree of patriotic enthusiasm arose in Scotland to encourage arts and manufactures, and the Edinburgh Society was established in 1755 for the express purpose of improving these. The records of this society show that the linen trade received a large share of attention. The finest linen cloth was made in the West of Scotland, and in order to obtain what was considered the best fibre of flax it was customary to pull the plant immediately after the blossom fell—a practice that was condemned by some economists as wasteful and otherwise unsatisfactory. "This kind of lint," they said, "heckles away almost to nothing, and is indeed very fine in appearance, but has no substance, and the yarn spun of it is weak and ouzy. It wastes much in the washing, and cloth made of it grows as thin as a cobweb in the bleaching, before it can be brought to a full colour."

At the same time it was remarked with regret that while the French spinning schools which had been established in the country bred very good spinners of fine yarn, a large proportion of these were persons of rank, who, when they had gratified their curiosity by learning the art, gave over the practice of it, and were of no more use to the manufacture.

The bounty on linen exported was stopped from 1754 till 1756, and during that time the trade fell off to a serious extent. About 8,000 weavers were thrown out of employment in Scotland, and many of these joined the army, whilst others emigrated. In 1770 and 1771 various circumstances stimulated the manufacturers to increase their production, and the consequence was that the markets were overstocked, and a period of depression ensued, during which nearly half the looms in the country were idle. The favour shown to the linen traders by the State was a cause of much discontent among woollen manufacturers, who considered that their commodities were the more natural and profitable manufacture of the country, whereas the natural seat of the linen trade was Holland, Flanders, Germany, and France.

With reference to the state of the Scottish linen trade about the year 1780, Mr. Warden says:—"It was spread over a great part of the country. In some districts there was little more made than supplied local wants, but in others the manufacture was carried on extensively, and large quantities of linen were sent to England as well as shipped abroad. Much of the flax used in the manufacture was raised at home, and Riga and Dutch flax was imported to supply the further requirements of the trade. The flax was chiefly grown by the cottier farmers, and the preparatory processes to adapt it for being spun were performed by their families. Spinning flax on the hand-wheel formed the principal occupation of females of all classes both in town and country, and some of them, from long practice, became great adepts in the art. The yarn was either weaved at home, or sold in the district markets, of which there were many throughout the country, to agents from the large towns, such as Dundee, Glasgow, Montrose, &c. It was either made into linen in these towns, or sent off to England and manufactured there. After the introduction of flax-spinning by power, the trade became completely changed. The spinster and the hand-wheel of last century gave place to the factory girl and the spindle of the present; the manufacture ceased in many rural districts, and became concentrated in towns where spinning-mills were erected, and in a few other places."

From the "Statistical Account of Scotland" we learn that at one time or other spinning flax and making linen cloth were practised in nearly every county. About the middle of last century flax was grown and spun in all the larger islands of Orkney. An attempt made to establish the trade in Zetland did not succeed, as the occupation of spinning was too sedentary for a people who spent most of their lives out of doors. The fact that the Orcadians exported 250,000 spindles of yarn and 30,000 yards of cloth every year, showed that they appreciated the benefits of the industry, and reaped a corresponding reward. One disadvantage, however, followed from the adoption of linen cloth as an article of clothing in those high latitudes. Rheumatism became a very common complaint, and coughs and colds afflicted everybody. In the most northerly parts of the Scottish mainland, flax was grown to a considerable extent a century and a half ago; but it would appear that the manufacturers outran the cultivation, and it became necessary to import quantities of the raw material. The Custom House books show that in 1794 and two following years over 120 tons of dressed flax were imported into Thurso. An attempt was made in 1851 to revive the cultivation of flax in Caithness-shire, as well as in some other counties of Scotland, but it was not successful. Flax and hemp were at one time cultivated in Ross-shire, and flax obtained from some of the Baltic ports was spun and woven in Sutherlandshire. An extensive hemp factory, which gave employment to a thousand operatives, was established at Inverness in 1765. The hemp was brought from Russia, and chiefly converted into sacking. Some years later a company was formed for the manufacture of linen thread.

As spinning machinery had not then been introduced, the work was done in the homes of the workpeople on the common wheel. No fewer than ten thousand persons were employed by the company; but the machines of Kendrew and Porthouse soon closed this enterprise. The wages earned by the spinners varied from 1s. to 12s. per week. The manufacture of linen prospered in the county, however, until 1822, after which year it gradually declined. In Nairnshire and Morayshire the people also devoted some attention to the cultivation and manufacture of flax. Banff, like Inverness, engaged in the thread manufacture for a time, and that branch gave employment to 5,000

persons. The thread made was sold chiefly to the lace-makers of Nottingham and Leicester.

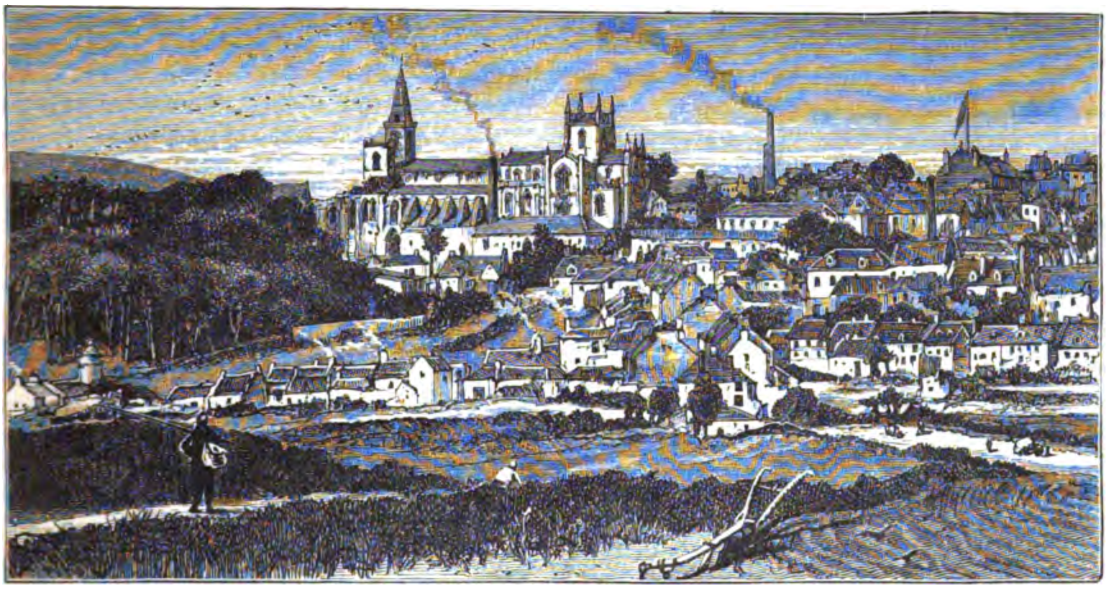
The Earl of Findlater, President of the Board of Manufactures in 1748, desiring to establish the linen trade in the parish of Cullen, set about it in this way:—He took to Cullen two or three young men, sons of gentlemen in Edinburgh, who had been regularly bred to the business, and who had some patrimony of their own. To encourage them to settle so far north he gave them £600 for seven years, the money to be then repaid by yearly instalments, free of interest during the whole period of the loan. He also built weaving shops, and furnished every accommodation at reasonable rates. From his position at the Linen Board he obtained for the young manufacturers premiums of looms, heckles, reels, and spinning-wheels, with a small salary for a spinning-mistress. In a few years the earl had the gratification of seeing his enterprise succeed to his highest expectations; but the success was only for a time, and, owing to influences which appeared to be irresistible, the trade in course of time passed completely away. Under the auspices of the Board of Manufactures, the linen trade of Aberdeenshire, which had previously been of little account, was considerably developed about the year 1745. Particular attention was bestowed on the production of sewing-thread, and in 1795 no fewer than 13,000 persons in the county were employed in that branch, the earnings of adults being from 5s. to 12s. per week. When spinning machinery was invented several mills were erected on the banks of the Dee, and proved successful undertakings. The quantity of linen cloth stamped in the county in 1758 was only 103,109 yards, but the make gradually increased, until in 1822 over 2,500,000 yards were produced. It is claimed for Kincardineshire that it was the first county in Scotland in which a flax spinning-mill was erected. The proprietors were Messrs. Sim and Thom, who obtained a license from Kendrew and Porthouse to use their machines.

Continuing our survey westward and southward, we find that attempts, more or less vigorous, were made to establish the linen trade in Kinross-shire, Argyllshire, Buteshire, Lanarkshire, Dumbartonshire, Mid-Lothian, and all counties to the south of these. In one or two quarters it prospered for a time, but ultimately gave way, as the people found what they believed to be more congenial and profitable occupations, and as the concentrating influence of the factory system came to be felt. Forfarshire, Fifeshire, and Perthshire are the only counties that have succeeded in retaining their early hold of the trade, and in developing it to an important extent. Statistics showing this were given in the preceding chapter.

In briefly sketching the rise and progress of the linen manufacture in Forfarshire, we leave Dundee to be separately dealt with, as its position as the chief seat of the trade in the kingdom requires. Arbroath stands next in rank, and its connection with the trade may be said to date from the year 1738, when an accidental circumstance laid the foundation of a branch of the manufacture for which the town subsequently became famous, and may be said still to enjoy a reputation. A weaver in the town had in his possession a quantity of flax which was not suitable for making the kind of cloth then in demand; but he, rather than lose it, worked it up into a web which he offered to sell to a merchant at a very cheap rate. On examining the cloth the merchant detected the similarity between it and the brown linen fabric known as "Osnaburg," which was imported from Germany, and the art of making which was not then known to weavers in this country. To the surprise of the thrifty weaver, he not only found a purchaser for the web, but an order to produce others of the same kind. When the fact got abroad that the secret of weaving "Osnaburgs" had been discovered, many weavers in the town acquired the necessary knowledge, and before long most of the looms were devoted to the production of the new fabric. In the course of a little time the brown linens of Arbroath became famous at home and abroad, for not only did the weavers learn to imitate the German article, but they improved upon it. Considerably over a million yards of brown linen were made in Arbroath in 1792. An attempt was made before that time to introduce the thread manufacture, but it did not succeed. Some persons engaged in the trade acquired a portion of a flour mill in 1807, and made experiments in it with flax-spinning machinery. These realised expectations, and the grinding machinery was entirely replaced by flax machines. Soon afterwards other factories were established. About the year 1820 there was a great demand for Arbroath goods, and it continued some time. Not dreaming that this run of prosperity could be of a temporary character, the means of production were enormously increased by the manufacturers and speculators. At the beginning of 1826 a reaction set in, and resulted in a complete collapse

of the trade of the town. Several years elapsed before a recovery took place, and since then matters have gone on more steadily. In 1842 the quantity of flax used in the factories of Arbroath was 7,000 tons, the weaving of which gave employment to over 1,200 men and women. There were eighteen linen factories in the town in 1851, and these contained 30,342 spindles, 806 power-looms, and gave employment to 4,620 persons. The returns for 1867 showed only a slight increase on these figures, nor has there since been any appreciable extension of the trade. Like other seats of textile industry, Arbroath has suffered from the depression of the last few years, but its trade had been established on such a healthy basis that a calamity like that of 1826 has been avoided. Montrose, like Arbroath, is engaged in the production of heavy linens and canvas, but also turns out large quantities of yarn to supply looms in other parts of the country. When Pennant visited the town in 1776, he particularly noticed the manufacture of sail-cloth, fine linen, lawns, and cambric then carried on. In his journal he says:—"The men pride themselves on the beauty of their linen, both wearing and household, and with great reason, as it is the effect of the skill and industry of their spouses, who fully emulate the character of the good wife so admirably described by the wisest man." The Forfar manufacturers have all along devoted their chief attention to weaving, procuring their yarns from other towns. Heavy and brown linens are their chief products, and for these the town has a high reputation. Between two and three million yards were stamped annually for a number of years prior to the abolition of the stamp laws. The hand-loom was long retained in use in the town, but is now all but completely superseded by the power-loom. The towns of Brechin and Kirriemuir have also retained a share of the trade in which they embarked simultaneously with other communities in Forfarshire.

Blairgowrie is the chief seat of the linen manufacture in Perthshire, more than half the factories in the county being situated there.



DUNFERMLINE.

In Fifeshire the fifty or sixty flax mills are grouped in Kirkcaldy, Dunfermline, the Leven district, the Eden district, and Tayport. Kirkcaldy being a convenient centre for trade, an annual market for the sale of linen was established there in 1739, and other means were taken to encourage trade. The first goods made in that town were handkerchiefs, checks, and coarse ticking. Owing to various circumstances the demand for these ceased, and the trade was on the point of being abandoned when Mr. James Fergus discovered a mode of making ticking of a superior quality. Finding a ready market for this, he and his fellow manufacturers applied themselves to its production, and so thoroughly did this branch of business become established, that the reputation of the town for

tickings endures to this day. Towards the close of last century, five large flax spinning-mills were built at Kinghorn, and others followed at Kirkcaldy and the neighbourhood. Mr. James Aytoun, whose name has been already mentioned in connection with Kendrew and Porthouse's invention, was a pioneer of flax-spinning in the Kirkcaldy district, and the author of some important improvements in the machinery.

Dunfermline has already been referred to as the chief seat of the linen damask manufacture, and the achievements of some of its weavers recorded. At an early date in its industrial history the linen weavers of this town vied with each other in the production of very fine or very elaborate pieces of work, and in 1718, James Blake introduced the art of damask weaving under the remarkable circumstances described in the preceding volume. He kept the secret to himself, however, for a considerable time, and sixty years after his piratical visit to Edinburgh only a dozen damask looms were at work in the town. It required three persons to work the damask loom in its earliest form—two weavers, one at each side, to throw the shuttle and move the "lay," and a boy to work the series of cords which raised the warp threads necessary to produce the design. The invention of the "fly shuttle" did away with one of the men, and an invention of Mr. John Wilson of Dunfermline provided for the draw-boy's work being done by mechanical means; other improvements followed, but these were superseded by the introduction of the Jacquard machine in 1825. The Dunfermline manufacturers paid great attention to the preparation of their designs, and in 1826 a drawing academy was established in the town with the view of educating young men to become designers. This institution did good service. The Board of Manufacturers gave special encouragement to the trade, and for a number of years awarded premiums for excellence of design in damask goods. In the course of eighteen years one firm carried off £516 10s. in the shape of premiums. The principal factory in Dunfermline is the St. Leonard's, which belongs to Messrs. Erskine Beveridge and Co.* There is no spinning department in the factory, all the yarns used being obtained from other places: indeed, there is very little flax-spinning done in the town. The factory is equal to turning out about a quarter of a million square yards of cloth every week, and gives employment to nearly two thousand workpeople, for whose comfort most liberal provision is made.

The Bothwell Power-loom Factory belonging to Messrs. D. Dewar, Son, and Sons, of London, is also a large establishment, and there are others on an extensive scale. Ten years ago there were a thousand hand-looms at work in the town, and three times as many power-looms, and the quantity of cloth made annually was estimated at over thirty million square yards, the value of which could not be less than two millions sterling.

SHIP BUILDING.—XXI.

TONNAGE MEASUREMENT FOR SHIPS.

THE use of the term "tonnage" in connection with the measurement of British ships for fiscal or other purposes can be traced back for at least five hundred years; and the first Act of Parliament for measuring ships was passed in 1422. Since then there have been seven other tonnage laws in force, some of them limited to particular classes of ships, others of general application. It is supposed that the term "tonnage" originated in a very simple fashion, in the old times when the import wine trade was of great relative importance, and the size of a ship was roughly estimated by the number of *tuns* of wine she could carry. In some of the older documents the term "portage" was frequently employed as a substitute for tonnage, and pithily expressed what we now term the "carrying-power" of ships. But as time passed on, and tonnage law superseded tonnage law, the varieties of "tons" were so multiplied as to cause confusion and frequent misapprehension. Sometimes a ton meant "dead-weight;" at others it meant "cubical capacity," determined by internal measurement, while at others it meant a certain fraction of the product of external measurements. Nor has this confusion entirely disappeared at the present time, as will be seen from what follows. The earliest English tonnage-law passed in the last year of the reign of Henry V., took the *ton weight*

* A view of the weaving-shed of this establishment and its thousand looms was given at page 25, Vol. II.

as a unit. Its chief application was to the barges or "keels" then employed in carrying coals on the Tyne. "From that time until now," says an eminent writer, "every keel contains 21⅛ tons of coals, and in the north of England the capacity of a ship is still better understood by the number of keels she can carry than by her registered tonnage." The second Act for measuring tonnage dates from the reign of William and Mary (1694), and by an Act passed in the reign of George III., its provisions were extended to all ports in Great Britain; but in both laws the measurement of coal-carrying vessels was alone provided for. Here, as in the older law, one ton of tonnage "represented absolutely a ton of weight," and the actual tonnage was measured by the very simple and primitive process of actually putting on board a ship known weights of iron, lead, &c., and "marking the tonnage on each side of the stem and stern post by marks and nails." A very similar practice still prevails among bargemen.

Still another tonnage law, passed early in the reign of George I. (1720), provided for the measurement of vessels employed in carrying spirits. This was a measurement of the approximate *internal capacity*, but it is unnecessary to give the details of the rule, since it was never extensively applied, and has been long obsolete. The next Act passed was that which became notorious under the name of "Builders' Old Measurement" (B. O. M.); it dates from 1773, and is the first law of measurement applied to all British sea-going ships. Long before the rule was legally enforced, it was very generally applied in tonnage calculations, but with various modifications, which somewhat affected comparative results. Its chief provisions may be very simply explained, and the explanation will be useful, as it will illustrate the evil effects upon British shipping which resulted from this mode of measurement. External measurements of the length and breadth only were taken in computing the B. O. M. tonnage. The *length* was taken on a straight line along the rabbet of the keel of the ship, from the back of the main stern post to a perpendicular line from the fore part of the main stem under the bowsprit. The *breadth* was taken from the outside of the outside plank, in the broadest part of the ship, exclusive of any additional thickness of planking or doubling strakes that might be wrought at that part. Then from the length was subtracted three-fifths of the breadth, the remainder being termed the "length for tonnage." This was multiplied by the breadth; their product was multiplied by half the breadth, and the result divided by ninety-four gave the tonnage. This divisor, ninety-four, had been in general use in all the earlier but non-compulsory rules, and had been employed in the tonnage law of George I. It was no doubt chosen originally from the belief that it gave a rough approximation to the actual *dead-weight carrying-power* of a ship. But when harbour, dock, and light dues were legally assessed according to the tonnage so measured, builders were not slow to avail themselves of the easy method of evasion which the B. O. M. law presented. It took no account of the actual *form* or *depth*, but assumed the depth to be half the breadth. Builders had simply to increase the depth, therefore, leaving the length and breadth unchanged, or to make the form "fuller" in order to increase the carrying-power without any increase in the legal tonnage. Instead of that tonnage roughly indicating the dead-weight that a ship could carry, it frequently was less than *two-thirds* the dead-weight carried. The result of adopting these proportions of depth to breadth was highly prejudicial to the safety and good sea-going qualities of British merchant shipping; but the evil was not fully realised for many years after the Act was passed. During the almost incessant wars with France British merchant ships usually sailed under convoy, and foreign shipping was almost swept from the sea. After the restoration of peace, however, the relative inferiority of the British type of ship, as compared with the broader and shallower types, built in the United States and elsewhere, became strikingly apparent. From that time the old tonnage law was doomed, but it remained in force until 1836 for the mercantile marine, and was used until 1872 for estimating the tonnage of ships of the Royal Navy. Even now it is not unusual to find builders' old measurement given in estimates for the cost of ships, although it ceased to be the legal measure forty years since. Such is the vitality of a mode of measurement which came into vogue centuries ago, and which originally served some useful purpose: but which, from the first, depended for its usefulness upon the retention of certain proportions of depth to breadth, and certain methods of construction. Resting upon no exact scientific basis, it was not capable of meeting the great and various changes in construction which have taken place during the last half-century; and it had, as we have seen, an injurious effect in hampering freedom of choice in designing new ships. It put a very severe penalty upon beam, and neglected depth entirely.

The law of 1836, known as "New Measurement," was amended about eight or nine years later, and remainèd in force until the present law was passed in 1854. It was designed to give an approximation to the *internal* capacity of ships, this approximation being based upon certain measurements of length, breadth, and depth. Very few measurements were taken, and consequently the builder found it easy to evade the spirit of the Act, by constructing his vessel at the few sections where the measurements were made, in some special way which led to a decrease in the nominal tonnage. There was no temptation under the law to increase depth at the expense of beam, and this was a great advantage over the old measurement. Yet the force of habit was so great, and the new measurement was open to such criticism, that it is said "many persons went back to the repealed old law, and on account of its greater simplicity bought and sold and hired ships by it." After eighteen years' continuance the new measurement gave place to another system, resembling it in principle but much more perfect in its details. Mr. Moorsom, who had been trained in the first English school of naval architecture, was the originator of the new system, and he became the Surveyor of Tonnage at the Board of Trade. This system, still in force, is known as "Register Tonnage." It determines in an accurate and easy manner the entire internal capacity of a ship in cubic feet; and this volume, when divided by 100, gives the *gross* register tonnage. A "register ton" is therefore simply 100 cubic feet of space, and has only a very indirect relation with dead-weight. The *nett* register tonnage, which is strictly speaking the tonnage inscribed in the register of British shipping, is intended to represent the space actually available for carrying cargo or accommodating passengers—in short, the space which is commercially remunerative. In sailing-ships the deduction from the gross to the nett tonnage is very small indeed, only representing the space occupied by the crew. In steamers the case is very different, for the spaces occupied by the engines, boilers, coals, &c., are deducted from the gross tonnage. This deduction has given rise to warm discussions, the owners of sailing-ships alleging that their vessels are unfairly treated as compared with steamers; while the owners of steam-ships insist that some abatement is necessary from the gross tonnage, because of the spaces occupied by the machinery and coals. It is not necessary to reproduce the arguments here, but it may be interesting to state that for ocean-going steamers the nett tonnage is about *sixty-four hundredths* of the gross tonnage.

The Moorsom system of tonnage has now been in operation for more than thirty years, and has given universal satisfaction. There have, of course, been discussions now and again between the Board of Trade and shipowners as to the propriety of including certain spaces in the nett tonnage; and with the rapid developments that have taken place in ship construction it is a matter for surprise that these disputes have not been more frequent. The principle of the system of measurement has never been questioned since it became understood. It leaves the naval architect quite unfettered in the choice of the principal dimensions and structural arrangements of a ship; and at the same time is difficult of evasion. Perhaps the weightiest testimony in its favour is its adoption by all the principal maritime nations, and by various International Commissions. Almost immediately after the Act of 1854 came into operation it was adopted by the International Commission for regulating the navigation of the Danube, as a basis for the dues to be levied on all ships. The Constantinople Commission for settling the tonnage upon which Suez Canal dues are levied, also accepted the Moorsom system. It has been legalised in the United States, France, Germany, Austria, Italy, Norway, Sweden, Holland, Denmark, Turkey, Spain, and Belgium. Russia is the only maritime power of any importance that has not adopted our system. It will, of course, be understood that identical allowances from the *gross* tonnage are not made in all these cases in order to estimate the *nett* or registered tonnage. So far as the calculation of the gross tonnage is concerned there is practical identity of practice; but beyond that point there are differences. In the United States no deductions whatever are allowed from the gross tonnage of sailing- or steam-ships. This was the view of Mr. Moorsom himself, and has been warmly supported by high officials of the Board of Trade in evidence given before Parliamentary Committees; but it has never found general acceptance elsewhere than in the United States. M. de Lesseps attempted to enforce the gross tonnage as the basis for payment of dues by vessels passing through the Suez Canal, but he was overruled by the Constantinople Commission; and the system now in operation both in the Suez Canal and on the Danube permits deductions from the gross tonnage for crew-space and machinery. The minimum tonnage upon which a ship can pay dues

in passing through the canal is 45 per cent. of her gross tonnage; but from 50 to 65 per cent. of the gross tonnage are not uncommon values for the nett tonnage, upon which the dues are paid. There are also additional charges for pilotage, &c., varying with the draught of water of a ship, it being assumed with fairness that a vessel of deep draught should pay more than a shallow-draught ship.

It has long been felt by persons familiar with mercantile affairs that great advantage would result from the establishment of a system of international tonnage, applying to the ships of all nations. From what has been said above, it will be evident that a close approximation has been reached in the tonnage laws of the principal maritime nations; and it seemed reasonable to suppose that the labours of the Constantinople Commission in 1872 would result in the establishment of some general law. This hope has not yet been realised, although an attempt was made in 1874 to amend the Act of 1854 in accordance with the arrangements approved for the Suez Canal. Strong opposition was offered to the change by influential shipowners, and the House of Commons Committee appointed to consider the Bill proposed by the Board of Trade simply took evidence. Perhaps at some future time a similar attempt to amend the law will prove more successful. The officials of the Board of Trade are strongly in favour of the change, and as they are well-informed and disinterested their opinion will certainly command respect.

In the number and efficiency of her yacht-squadrons Great Britain stands alone. The United States come next in order, and France is devoting much attention to the encouragement of yachting, but we may be justly proud of our supremacy. It is a notable fact, therefore, in connection with English yachts that their tonnage for competitive sailing is usually computed according to a rule which is only a slight modification of the B.O.M. tonnage law previously criticised. The Thames Rule for tonnage is that generally adopted, or the slightly different rule of the Yacht Racing Association. According to the Thames Rule the length is measured on the deck from the fore-part of the stem to the after-part of the stern-post; the breadth is the extreme breadth measured to the outside of the outside plank. From the length the extreme breadth is deducted, the remainder is multiplied by the breadth, and their product by half the breadth; this final product being divided by 94 gives the tonnage. The Rule of the Yacht Racing Association departs from the Thames Rule only in measuring the lengths of yachts on the load water-line instead of the measurement on the decks. Neither of these rules can be said to rest upon a scientific basis, but they are strongly supported by the great majority of English yachtsmen. There can be no doubt but that the English type of yacht is safe and seaworthy, as well as commodious. And it is obvious that as yachts are measured for racing purposes by these rules an owner has every inducement to make her well-formed, in order to increase her speed. This circumstance prevents evil from following the adoption of rules which on scientific grounds are as indefensible as the builders' old measurement, from which they spring.

There have been various proposals for change in the mode of measuring yacht tonnage; and while English yachtsmen have been most conservative, their American brethren have accepted many changes. One of these has been repeatedly recommended for adoption in this country, viz., the use of "displacement" or the "total weight" of yachts as their tonnage for time allowance. As it has never found favour in England, we need not say much respecting this mode of measuring yachts; but it is clear that the plan is simple and scientific. On the other hand it is urged that American yachts, built to sail under the displacement rule, are not nearly so safe or commodious as English yachts; and that they are really nothing more than "racing machines." Who shall decide between such rival claims?

Still another proposal which has been warmly advocated by several authorities, is the use of *sail-areas* as a measure of efficiency in match sailing. It is urged that since, with a given force of wind, the propelling effect should vary with the sail-spread, the excellence of a yacht is to be judged by the speed she can attain with a given spread of sail. That yacht should, therefore, be counted superior which can attain a certain speed with the smallest sail-spread. In other words, a vessel with the larger sail-spread ought to attain the higher speed, and should allow "time" to a vessel with less spread of sail. Various objections have been urged against this proposal. It must suffice here to add that it has never become the law in England, although, in America, an approximation thereto was formerly in force. Respecting yacht tonnage, one additional remark must be made. Whatever rule be adopted, it will be certain to result in the construction of the type of yacht which is best adapted for sailing under that rule; and questions of accommodation or seaworthiness are likely to be

put into the second place. At present there seems no prospect of any radical change in the method of measuring tonnage for English yachts.

For ships of war, the tonnage measurement now universally adopted is the *load displacement* in tons avoirdupois—that is to say, *the total weight* of the ship and the lading when she is fully equipped. This is a very convenient and trustworthy method for ships designed, as war-ships are, to carry certain known maximum weights. Their case is not at all comparable with that of merchant vessels built to carry cargoes, which may vary greatly in weight and bulk from time to time, and wherein, as a rule, the possession of large internal capacity is a very great advantage. Displacement tonnage has been advocated for merchant ships, but there is the great difficulty of fixing the maximum load-draught for a merchant ship; and, after many endeavours to frame a simple rule for freeboard, the attempt has been abandoned. For the same reason, no practical result has followed the repeated recommendations that the tonnage of merchant ships should be reckoned by the *dead-weight* they can carry. This, as we have seen, was the original mode of legal tonnage measurement, and was approximately what was expressed in the builders' old measurement when first introduced. If the maximum load-draught of a ship could be fixed, and her draught was known when she was floating light with no cargo on board, it would be the simplest possible calculation to estimate what dead-weight would have to be put on board to bring her down from the light to the load-draught. But as the load-line cannot be absolutely fixed, the estimate of dead-weight can only be approximately performed. The ship-builder can, of course, say at what draught the vessel should float when she has a certain dead-weight on board; but that is a distinct question.

Lastly, it may be well to mention that merchants and shippers, when engaging freight, commonly use the term "tonnage" in a sense differing from any of the meanings explained above. For their purposes a "freight-ton" means 40 cubic feet of space, or *two-fifths* of a register ton.

In concluding these remarks, we cannot refrain from expressing the hope that the brief explanations given of the various kinds of tonnage measurements which have been, or are still in force, may be of some service in rendering clear statistical and other statements relating to tonnage, which are often misunderstood.

HEALTH AND DISEASE IN INDUSTRIAL OCCUPATIONS.—VII.

COTTON AND SILK WORKERS AND THEIR DISEASES.

BY ANDREA RABAGLIATI, M.A., M.D., HONORARY SURGEON TO THE BRADFORD INFIRMARY.

DISEASES of the lungs prevail to a large extent among cotton operatives, and are due, like those of woollen and flax workers, in great measure to the dust given off by the raw material, particularly in the carding processes. As I have dwelt at some length in previous chapters upon the deleterious effects of this agent, I do not propose again to go into the details of the subject, beyond stating the fact that, particularly where low-class cotton is used, a large quantity of "flying," "fluff," or "flue" permeates the air of cotton factories. A large quantity of it collects upon the hair and clothes of the workpeople; and Drs. Bridges and Holmes, in their report to the Local Government Board in 1873, showed that the quantity of this fluff was so considerable as in five minutes to be sufficient to coat over a clean, smooth metal surface so thickly as to allow of marks being made upon it. In order to avoid repetition I must, therefore, ask the reader to apply the remarks already made upon wool workers to cotton operatives, only substituting the word *cotton* for *wool* where it occurs in the description; but in order to show that it is not only in English factories that these conditions exist, I introduce here some remarks by a German writer on this subject, published in the report above named.

"Soon after the entrance into the workshop the workman perceives it [the fluff] in a most unpleasant way; in those unaccustomed to it, it causes continual tickling in the throat, which incites hard coughing, and occasionally whitish expectoration. In the first year of his work the operative suffers constantly from bronchial catarrh, and a considerable proportion of those who come to this occupation from rural districts abandon it, even though they may be sufferers from constant catarrh only without other worse symptoms. If, however, they persevere in this

occupation, more important symptoms supervene, sometimes soon, often after a year of work: such as cough with pectoral pain, marked anæmia, obstinate debility, and loss of appetite. White viscid sputa are now expectorated with difficulty, which show, under the microscope, cotton fibres for several hours after quitting the factory. Marked emaciation, sometimes, but rarely, caused by profuse diarrhœa, deprives the operator of his strength, and compels him to leave his work and betake himself to his home or to the hospital.

"These, of course, are the most unfavourable, and, happily, not the most frequent cases. But people very often go on coughing their whole life long, and die at an advanced age of some inter-current disease. So far as we have observed they never remain free from cough or in perfect health," and so on, but enough has been quoted for my purpose.

While on the subject of dust, I wish to mention two special kinds of it to whose evil effects cotton workers are specially exposed. These are *débris* of metal and china clay. Reference to these things requires explanation, which, however, is easily supplied. The metal dust is given off in the process of sharpening the teeth of the cards, which soon become blunted in the performance of their work. Sharpening is effected by the friction of emery against the teeth, the operation being performed either by hand or by machine, according to the size of the mill and other incidents. In either case the metallic particles given off and inhaled by the operatives act hurtfully, not only from their properties as dust, but specially by means of their sharp cutting edges, which speedily destroy the portions of lung tissue with which they come into contact. This metallic dust, however, as it affects only that portion of the workers who are engaged in grinding the teeth of the machines and the comparatively small number in their immediate neighbourhood, is less powerful for evil than that given off in the weaving-room by the china clay, to which some further reference is desirable. This agent began to be used about the year 1851, before which time it had been customary to "size" cotton, for the purposes of weaving, with flour and tallow. Some manufacturers who used inferior flour found that they could reduce the brown colour of the cotton thus produced by the admixture of a certain quantity of china clay; and they further found that the china clay so far reduced the glutinous quality of the flour that the sized warps would weave easily with a less amount of tallow in the size. The Russian war in 1854, by increasing the price of tallow, led to a further use of china clay. In 1862 came the American war and the cotton famine, when the high price of cotton induced the manufacturers to use inferior sorts. These low-class cottons, being short fibred, required a larger amount of size for weaving, and the high price of cotton still continuing, manufacturers got into the way of keeping up the weight of their pieces, not by the quantity of cotton, but by adding more size. Next, in order to prevent the large amount of size from glueing the fibres together, it became necessary to add some substance which, like common salt (one of the materials employed), should have the property of keeping the mass moist, so as to prevent the compound from breaking in the manufacture. These salts are called by the general name of "antiseptics." The composition of the size thus comes to consist of china clay, some fatty substance, and one of the antiseptics, to which is sometimes added a portion of animal glue or resin. About one-third of the size consists of china clay; and the proportion of size, by weight, to the warps varies from fifty to ninety per cent.: that is to say, in a quantity of warp weighing ten pounds, nine pounds may consist of size and one pound of cotton; while of the nine pounds of size, three or more may consist of china clay. Now, however the size may be composed—whether, that is, it contain more or less clay or more or less tallow—a certain amount of the clay comes off as dust in the weaving; but the less flour and tallow there are, the more dust is given off; and a large quantity of dust is also given off when the deliquescent salts or antiseptics are used.

Another matter, having an important bearing on health, arises out of this. In order to weave at all the over-sized warps it is necessary to keep them moist. This is effected partly by the deliquescent salts, but in some cases by injecting steam into the weaving-sheds through perforations in the steam-pipes by which they are heated. This keeps the material moist, and also the air of the weaving-shed. The consequences are that the cotton weavers pursue their avocation in rooms whose air is charged with moisture almost to saturation, whose windows are not opened lest the air should be dried, and in which the air is loaded with clay dust, which is continually breathed by the workers. If any combination of circumstances could be much more injurious to human health, I should like to know what it is. It is possible, of course, that neither employers nor employed are fully aware of the hurtfulness of these conditions; some of the

former, we know, lament very much the over-sizing, and consequent evils which are taking place, while some of the latter complain bitterly of the results.

It is for the moralist to determine whether the gain obtained by reducing the cost of the cotton goods is worth the price paid for it in the deterioration of the health of the operatives; the political economist should make it clear that business does really benefit in the long run by proceedings such as these; the medical man must content himself by pointing out the inevitable effects on health.

The last unhealthy circumstance in the work of the cotton operative to which I shall refer is over-heating of portions of the factory. Both the carding and spinning-rooms are hot, the temperature of the former varying from 70° to 75° F., while that of the latter ranges from 92° F. to 105° F. There are three reasons given why the ventilation of the spinning-room is, generally speaking, bad. In the first place, it is admitted by both employers and employed that a considerable amount of heat is necessary for good spinning, especially for that of fine fibres. As the heat is supplied by means of steam-pipes, motives of economy require that as little should escape from open windows as possible. Secondly, the fine threads, it is said, would be broken by the current of air which would gain access to the spinning-rooms if the windows were opened. And thirdly, as the air of manufacturing towns is mostly sooty and dirty, it is alleged that the fine white cotton would be soiled by a too free access of such air to it. Now, if any one will attempt to realise to himself the meaning of working in winter in a room heated to 100° F., he cannot fail to be struck by the result. Heat acts on the tissues of the human body, as it does on other things, as a relaxing agent. The consequences, therefore, of exposing the body for a length of time to a heat of 100°, are that all the insensible pores of the skin are opened, that the muscles are softened, and that all the tissues are relaxed. Perspiration comes on, the breathing is quickened by the heat and work together, and so is the heart's action. Prolonged exposure to such a temperature, no doubt, permanently debilitates the whole frame. But it is not permanent exposure I am now considering; it is, rather, the alternation or change of temperature from hot to cold, from the heat of 100° F. to an external heat of, say, 35° F. We must remember, further, that this is not all; not only does there take place this fall of temperature of 65° in the air surrounding the cotton operative, the fall further takes place *suddenly*, and the effect of this is a sudden abstraction of heat from the over-heated, relaxed, perspiring body, and the sudden withdrawal of heat, not only from the surface, but from internal organs, such as the lungs, stomach, and intestines. The consequences are inflammatory attacks of all kinds—"colds," as they are called—aggravations of the chronic, recurrent bronchial catarrhs, and lung inflammations, to which we have seen that factory operatives are subject; and, besides, acute or sub-acute attacks of colic, and inflammation of internal organs in general.

In addition to this necessarily high temperature of the spinning-room, there is carried on, in the case of certain cotton yarns, a process which tends still further to heighten the temperature and to vitiate the air. This process is termed "gasing," and consists in passing the thread rapidly through gas jets, in order to burn off the loose fibres attached to it. The rooms are apt to be close and to smell of gas, and there is reason to think that the effects are prejudicial to the health of the workers. It ought to be said that the over-heating, deficient ventilation, and over-sizing which have been described are not practised in the best mills, nor is it the custom in them to saturate the air with steam to counteract the effect of sizing. Still, the description given conveys on the whole a just account of what is, to say the least of it, far too common a condition of things obtaining in cotton manufacturing, and it cannot be denied that it is a very melancholy one; and what makes the matter worse is that most of the suffering entailed on the workers is caused by the attempt to produce not good but bad work; and the worse the work the more the suffering.

Silk manufacturing is divided into the two departments, totally different from one another, of the manufacture of raw silk and of silk waste. Among the operatives in the former process no particular diseases prevail. There is little or no dust generated; close and hot working-rooms do not exist, because heat renders the silk electric and difficult to work. There is no particular evil arising from sizing; and though in summer the floors of the factory rooms are occasionally damped, in order to obviate the electric and repellant condition generated in the silk by the heat of the weather, this is not carried so far as to endanger the health of the operatives.

In the manufacture of silk waste the conditions are different. There is a large quantity of dust given off in the process of "dressing," to which the

silk is subjected after the gum has been first boiled out of it; and this has its well-known effects. In a silk mill I have visited "gasing" is employed as one of the steps in the manufacture, but the closeness and heat so caused are not by any means so perceptible as in cotton working. On the whole, it may be said that silk manufacturing is not an unhealthy occupation.

As to the remedies for the evils arising in the course of the cotton manufacture, each hurtful agent can be combated separately. The metallic dust given off by the grinding of the carding machines can easily be rendered harmless by the use of magnetic respirators, a remedy which would have been more generally adopted but for the prejudices of the operatives. The remedy for the cotton "fluff" and unavoidable dust given off in the carding-room is fans, properly placed so as to draw or drive the dust through flues into the open air. The necessarily warm rooms in which cotton spinning is carried on might be ventilated and still kept warm by admitting air into them through warmed chambers, an arrangement which exists in many private houses, and which could much more easily be carried out in a mill, where the surplus heat from furnaces and boilers, now so constantly wasted, might thus be utilised. Such a plan would also be compatible with filtration of the air through calico before its admission to the mill, by which means the sooty particles and other filth it contains might be removed, so preventing the soiling of the fine white cotton and the irritation of the breather's lungs. Gas effluvia might be carried off, as is done in some of the best mills, by waste flues, the heat from the gas keeping up a constant current through them. In order to reduce the danger of taking cold by the sudden exposure to the open air of the operatives who work in the hot spinning-rooms, I would suggest that they spend ten to fifteen minutes in the carding-room before going out, so as gradually to cool the body, after the fashion followed in the Turkish baths. As to the dust arising from over-sizing, and the steam bath necessary to the weaving of warps so treated, I have no suggestion to make but the obvious one of a little more honesty.

WOOL AND WORSTED.—XIX.

THE FINISHING PROCESSES—SHEARING OR CROPPING.

By William Gibson.

ANYONE who has seen a sealskin undressed, and the same hide after being manipulated by a skilled workman, will have some idea of the advantage which a piece of cloth derives from shearing. As has already been described, innumerable filaments of wool are torn up from the body of the cloth by the teaseling machines, so as to form a pile of fur, but these are of varying lengths, straggling in appearance, and, if left in that condition, would attract quantities of dust which it would be very difficult to brush out. The design of shearing is to reduce the fibrous pile to a uniform length, and there is as much difference between the piece after and before it has undergone the operation, as there is between a carefully mown lawn and the space of ground covered with a rank growth of herbage out of which it was formed. Besides this, sometimes cloth could not be thoroughly teaseled unless the longer fibres raised were cropped, so as to allow the spikes to penetrate deeper, and increase the thickness of the artificial fur.

As in all the other processes in the woollen manufacture, this was, up till the beginning of the present century, entirely done by manual labour, and a good cropper was worth his weight in gold. Indeed, when we remember the huge and unwieldy shears which he had to wield, the evenness of the surface produced was something marvellous. The *modus operandi* was very simple. Upon a large table, the top of which was stuffed with some elastic material and covered with leather, the cloth to be cropped was stretched and held in its place by weights attached to pieces of thong and fastened to the "lists" with hooks. In the case of broad as well as narrow widths two operatives worked together on opposite sides of the table. The cropping tool, as just stated, was unwieldy in the extreme. It was a pair of shears, with blades about half a yard in length, attached to a strong bow or semi-circular spring, something resembling those scissors formerly used by hand-loom weavers, though of course much larger, with the ends of the blades cut square, instead of being pointed. But unlike ordinary scissors the blades were not parallel

to each other. One—called the "ledger" or "male" blade—was flat; the other—named the "female" or "cutting" blade—was set at an angle of about 45°, and so arranged that when closed it fell slightly over the whole length of the flat edge of the other. As the spring or bow was very strong, unless the blades had been fastened so that they could not fly more than an inch apart at the edges, the workman would have been unable to use them. This was done simply enough by screwing a piece of wood about the middle of the flat blade, and another, in which a handle was fixed, on the back of the other half way along. A stout leather thong having been made fast in one piece of wood, was tied round the handle fixed to the cutting blade, so as to keep the edges the desired distance apart. The distance of course varied according to the taste of the workman, but it was rarely more than an inch. It will easily be conceived that when the flat blade of the shears was laid upon the piece of teaseled cloth, the filaments would rise above the edge, because by the dead weight of the tool it would sink a certain depth into the pile, and then, when the other blade was forced down upon its fellow, the filaments could be cut a uniform length. The workman then placed his shears upon the "list," the blades in the direction of the length of the piece, while his companion began at the opposite side in the same way. Passing his right arm through the bow of the shears as far as the elbow, and laying it along the back of the female blade, he grasped the handle to which the thong already described was tied, and had thus complete control over the motion of the blade. With his left hand he kept the other blade flat upon the cloth, and at every snip cropped the straggling pile to a uniform length till he reached the middle of the piece, where he was met by his companion. Having thus cropped as much as the length of the blades enabled them, they started a fresh length, and continued till the "stretch" on the table was completed. Drawing forward a fresh section, the operation proceeded till the entire piece was finished. Naturally, great skill and care were required to keep the surface even, to obviate the slightest deviation in the cut, and to guard against one "stretch" being more closely cropped, "by the estimation of a hair," than its predecessor, or that succeeding. All this a good operative managed perfectly, and the result was an absolutely uniform length of pile. The closeness of the "crop" was regulated by weights laid upon the flat blade of the shears, which pressed the tool farther into the pile. A piece of cloth could not be shorn with the desired state of finish by being gone over once, but it had to be passed over again and again. The first "cut" was done when the cloth was damp, after which it was hung out to dry, and carefully brushed, so as to get rid of the *débris* and to raise the pile for the next. The most popular stuffing for the top of the table was horse-hair, and it was necessary that great care should be taken to distribute it evenly upon the wood, as the slightest inequality would spoil the "cut," if indeed it did not cause the workman to cut holes in the cloth. Accidents of this kind occasionally occurred; and we daresay our readers who have watched a tailor's cutter at work have noticed that he carefully examines the cloth he is dealing with, so that he should not lay his pattern upon any flaw.

Although the fact was only discovered a few years since, that great painter and universal genius, Leonardo da Vinci, centuries ago gave his attention to cloth cropping, and invented a machine for doing the work which, strangely enough, anticipated by five hundred years, those constructed about the middle of the present century. Among his twelve MS. volumes of jottings which show that he was almost as great an architect, engineer, logician, poet, and mechanician, as he was a painter, is one at present in the Bibliothèque Nationale at Paris. A bookworm looking over it a few years ago, came across a drawing of a curious machine. He noticed its general features, but as it did not interest him he never thought of reading the note underneath it. Happening to go through the Exhibition of 1867 a few weeks afterwards, he saw at work a helicoidal cropper, and was struck with its general likeness to the drawing in Da Vinci's note-book. He mentioned the fact to a gentleman interested in manufacturing industries, and upon the latter being shown the drawing he at once saw that the celebrated Italian had centuries before invented a machine upon the principle of those at present in use, and on the note being read this was placed beyond all doubt. Yet the invention had lain unheeded till its worth was no longer of any value. But it is remarkable that the mechanical ingenuity of five hundred years had been unable to improve upon the thought of the painter, and that the most perfect machines of to-day are, in their essential features, constructed upon the same lines as his. What is equally strange is that none of the hundreds of persons who must have looked over the volume ever saw the value of the painter's suggestion; and there seems no reason to suppose that the ingenious person who, some sixty years

ago, hit upon the idea of a helicoidal cutter, had any knowledge of the similar proposal of Leonardo da Vinci. Had the interesting discovery been utilised sooner, many clumsy and unsatisfactory machines would never have existed. The first attempts to do by mechanical aid what had always been accomplished by manual labour and the huge shears of the cloth cropper, was made by a Mr. Harmar of Sheffield in 1787. The idea was an obviously simple one, but the result, it must be confessed, was far from satisfactory. The Harmar machine was, in fact, nothing more than the mounting of two pairs of enormous shears, identical with those used by croppers from time immemorial, in a square wooden frame. The blades were long enough to cut right across a narrow piece of doeskin. Each pair of shears was fastened to the sides of the frame, and attached to the cutting blade was an iron arm, connected by a rod to a spindle, in which were a couple of small cranks, of such a depth that when the spindle was made to revolve the arm was pulled down far enough to bring the edges of the shears in contact. The piece of cloth was made to pass over a flat, narrow piece of wood under the shears, and this was movable, so that the closeness of the cut could be regulated. As the cloth passed over these, the pile was pressed against the ledger blade of the shears, and the arm attached to the other being drawn downward by the crank, the pile was shorn as in the manual operation. Mr. Fryer, another Yorkshire manufacturer, invented a similar machine for cutting broadcloth in 1802. Here the idea of Mr. Harmar was utilised, the only distinction being in the construction of the shears. Mr. Fryer's shears had a ledger blade a yard and three-quarters long, and the "cutters" were half the length; or, in other words, Mr. Fryer joined the flat blades of the Harmar shears, and left the upper ones divided. The crank mechanism was copied, and the mode of making the cloth pass under the flat blade of the shears repeated. These machines did well enough for rough cutting, but after they had cropped as close as possible, it was generally found necessary to have the piece finished by hand.

In 1815, however, Mr. Price, of Stroud in Gloucestershire, constructed the first rotary cutter which was ever set in motion, and the means he employed were, as has already been said, the same as those suggested by Leonardo da Vinci 500 years before. He conceived the possibility of making the piece of cloth pass under a fixed flat blade, and of operating upon the pile by a number of blades set spirally round a small cylinder rotating above it. He set to work and constructed a machine, but it was years before he brought it to such a state as to get manufacturers to use it, and he never succeeded in making it perfect. However, he had given the mechanician a happy idea, and successors rapidly improved upon the original design, till it has been brought to such automatic exactness that a piece of cloth can be cropped with a degree of perfection far exceeding that ever reached by the most talented operative. The reader will understand the construction of the helicoidal cutting apparatus by looking at a similar contrivance in a lawn-mower. In these mowers the cutting cylinder revolves behind a wooden or iron roller which presses the grass flat as the gardener pushes the implement before him. Immediately the blades of grass are released by the roller they spring into an upright position, and the tips are nibbled off by each blade spirally fixed round the rotating cylinder. Mr. Price made his helicoid long enough to stretch across a piece of broadcloth, and so arranged the blades that when the first had finished its work the next one was ready to begin its cut at the opposite "list," or piece. The fixed blade was a piece of steel about three or four inches wide, and the same length as the cutting cylinder. The "bed" over which the cloth passed was a rounded bar of iron covered with several layers of felt or cloth. The piece was kept stretched by wheels, round the circumferences of which were bound pieces of leather containing spikes, and as the wheels slowly revolved, the spikes thrust themselves into the lists and prevented any wrinkling or puckering as the cloth passed over the bed. Two rollers were placed one at either end of the frame, and as the piece unwound from one it was wound on to the other. The workman had an assistant who brushed up the pile before it reached the cutting apparatus, but as Mr. Price had no motive power that enabled him to get more than 200 revolutions per minute for the helicoidal cylinder, the ingenious appliance had not, till the steam engine was introduced, fair play. However, the rotary cutter was an immense improvement upon its predecessors and soon increased in public favour. No sooner was the machine of Mr. Price found suitable, than mechanicians all over the world set themselves to improve upon it. Amongst those who were early in the field may be mentioned Mr. Douglas, of Paris, Mr. Lewis, of Boston, U.S., and Mr. Eli Jonathan, of Leeds. Many others have since been engaged in perfecting the mechanism and introducing new features, but

the essential characteristics of the most modern rotary shearers bear a striking resemblance to the drawings accompanying the patent specification of Mr. Price.

Manufacturers have preferred one of two classes of cropping machines—either that with a transverse action, which shear across the width of the piece, or that with a longitudinal motion, which cut along the length of the cloth. The first notable improvement upon the Price shearer was a French invention with a transverse action. The frame of the machine was a parallelogram, and the cutting apparatus was made to travel across the piece by a carriage working in endless screws. The helicoidal cutter revolved very rapidly, and the cloth was stretched between a pair of clamps which nipped each list as it lay upon a stuffed flat wooden surface. But, although the cutting cylinder made between 400 and 500 revolutions a minute, time was lost in moving the carriage on which it was mounted from one selvedge to the other at every fresh stretch; still, it did its work remarkably well, and found great favour. The next step was to return to the longitudinal action, the cutting apparatus being fixed, except that the helicoid revolved upon its axis. The piece of cloth was sewn into an endless band and revolved continuously till the cropping was complete, and by this machine some 500 yards of cloth could be shorn in twelve hours. Hitherto hand brushing had been invariably retained, but between 1840 and 1850 circular rotating brushes were added to the mechanism, and since then all the efforts of inventors have been confined to improving the feeding and cutting apparatus. We can only give a rough general idea of what has been done in these directions. The most perfect action yet introduced in the cutting apparatus is the invention of a mechanician of Lille in France. Between the "bed" and the "fixed" blade he left a space. Over the vacancy the helicoidal cutter is fixed, and underneath it revolves a small cylinder which presses the cloth close under the "fixed" blade, and helps to give the pile a certain resistance. The helicoidal cutter runs at a speed of 1,000 revolutions per minute, so that if it is armed with six blades 6,000 cuts per minute are attained, and this increases proportionately with the number of blades set in the cylinder. It is said that by this machine 700 yards of cloth can be cropped in ten hours. In Yorkshire the newest shearers have two or more sets of cutting tools, so that the work is done in one half, one third, or even a quarter of the time needed when only one helicoid is used. The most recent machines have a brushing apparatus attached, so that when the cropping is completed every particle that clings to the pile is cleared off. These brushers are simply a pair of circular brushes revolving on spindles.

In the Great Exhibition of 1851 there was shown a combined fuller, teaseler, and shearer. It was a very complicated piece of mechanism, but was characterised by considerable ingenuity, and, had it been found workable, might no doubt have effected a saving of time and cost. Its chief feature was that the piece of cloth after being milled, passed over a series of hollow cylinders charged with steam so that it might be dried before reaching the teaseling and shearing gear.

INDUSTRIAL LEGISLATION.—X.

SIR ROBERT PEEL AND THE TEN HOURS BILL—A NEW GOVERNMENT PROPOSAL—SUGGESTION OF THE HALF-TIME SYSTEM FOR CHILDREN—THE FACTORY BILL OF 1844—PROPOSED RESTRICTION UPON THE WORK OF ADULT WOMEN—NARROW DIVISIONS IN THE HOUSE OF COMMONS.

By James Henderson, one of H.M. Superintending Inspectors of Factories.

ALTHOUGH the correspondence between Sir Robert Peel and Lord Ashley made it clear that an irreconcilable difference of opinion existed between them on the subject of the Ten Hours Bill, the friends of this measure did not despair of its success. The agitation in its favour throughout the manufacturing districts was vigorously maintained, and the members of the Cabinet were dunned with deputations and with memorials on the subject, both individually and collectively. The defects in the Factory Act of 1833 were frankly acknowledged by the Government, but it was not until the session of 1843 that they ventured upon introducing a Bill to amend it. On the 7th of March Sir James Graham, the Home Secretary, explained its provisions to the House of Commons. In respect to the employment of children in factories, Sir James, in this Bill, proposed to introduce what has come

to be known in factory labour as the half-time system: a combination of work and education, from which the very best results have been obtained during the last five-and-thirty years in the textile manufacturing districts. The hours of work for children were reduced by this Bill from eight to six and a half in any one day; and it was provided that they must be taken either in the morning or in the afternoon, but not in both. This left the child who was at work in the morning free to attend school in the afternoon; or *vice versâ*, the child who worked in the afternoon was free to attend school in the morning. Sir James Graham accompanied this suggestion of a reduction in the children's hours of work by a proposal that the minimum age at which a child should be admitted to employment in a factory should be reduced from nine till eight. The Bill also proposed, in accordance with the recommendation made by the Select Committee, to extend the protection of the Act to females under twenty-one years of age, the Factory Act of 1833 having fixed upon eighteen as the maximum. The definition of male "young persons" it was not proposed to alter, and their legal hours of work were fixed at twelve on the first five days of the week and nine on Saturday. The privilege to make up lost time was to be confined to factories in which the machinery was driven by water-power. Provision was also made, for the first time, for fencing the machinery in factories, and thus guarding against the numerous accidents from which the workpeople suffered.

This first effort on the part of Sir Robert Peel's Government to deal with this important question thus embraced some novel and interesting features. It did not satisfy the advocates of the Ten Hours Bill, it is true, but it commended itself to many warm and consistent friends of the factory operatives. The Bill failed, however, on account of the "religious" difficulty respecting the education of the factory children. As the suggestions made by Sir James Graham on this point may be regarded as the germs of our present national system of education, it may be interesting here to repeat his own explanation of them. He proposed that "in five days out of the seven the children should be educated for three hours, either in the forenoon or in the afternoon. By the existing law no notice was taken of the place where the education was given, or of the system of instruction that was adopted. Now it was proposed by the present Bill that the Privy Council should have the power to appoint inspectors to visit the schools to which certificates were granted; and on receiving a report from the inspectors as to the inconvenience of the place, or as to any objection in the method of education pursued, the Privy Council were empowered to notify to the schoolmaster the defect so reported, and unless within three months that defect should be remedied, the Privy Council would have the power of stopping the grant made to the school."

This proposal brought a new element altogether into the controversy, with respect to the regulation of labour: a controversy which may be said to have been waged incessantly for thirty years, and which the passing of the Elementary Education Act of 1870 has not altogether allayed. The Dissenters throughout the country generally at this time were altogether opposed to State interference with elementary education. They were jealous—and had undoubtedly substantial ground for their jealousy—that whatever arrangements would then be made upon the subject, an advantage would be given to the Church of England. Neither the legislature nor the nation was prepared to assent to such a liberal compromise upon this important question as was found practicable nearly thirty years afterwards. The educational clauses of the Factory Bill of 1843 provoked such an amount of opposition that the new Government, strong as it was, resolved not to press them. On the 15th of June, Sir James Graham intimated that all his efforts to conciliate the representatives of the various dissenting denominations had proved fruitless, and ultimately the Bill itself was withdrawn for the session. Lord Ashley, before the House of Commons rose, however, elicited from Sir Robert Peel the explanation that the Government had resolved to postpone the Factory Bill, not because they had any doubt of its importance or propriety, but simply to meet a desire, expressed on both sides, that its provisions should be more fully discussed. An assurance was further given that a new Bill would be introduced at an early period during the next session.

Some disappointment was felt at this delay, and some suspicion was entertained of the sincerity of the Government. Mr. Charles Hindly, member for Ashton-under-Lyne, gave notice the same day that the Government measure was withdrawn of an independent Bill to amend the Factory Act, but at the request of the Home Secretary he withdrew the notice.

The session of 1844 was an eventful one in the history of factory legislation. The friends of

the Ten Hours Bill had sustained the agitation throughout the country in its favour with remarkable success. It was quite well known that the Government Bill would not meet their views upon this point, but this neither daunted their courage nor altered their determination to press for this concession. Lord Ashley, it was equally well understood, would propose an amendment upon Sir James Graham's Bill in favour of a limitation of the working hours to ten in the day, and large and enthusiastic meetings in support of this amendment were held throughout the manufacturing districts. The Government faithfully fulfilled the pledge the Prime Minister had given the previous session, and the Government Bill was introduced into the House of Commons so early as the 6th of February. From the speech of the Home Secretary it was evident that the new Bill was drawn very much on the same lines as that of the previous year. Children were to be allowed to work half-time from eight to thirteen years of age, and the hours of labour for young persons and women were limited to twelve for the first five days in the week and nine upon Saturday. The educational difficulty was got over by a compromise.

The factory inspector was substituted for the Privy Council as the judge of the efficiency of the school and of the schoolmaster.

The most remarkable change introduced was the proposal made by the Government to extend the protection of the Factory Act to adult women. The wisdom of such a restriction has of late years been widely questioned, and it is not unlikely that it may yet become the subject of discussion in the legislature. In view of this, it is interesting to know that the proposal was a spontaneous one on the part of Sir Robert Peel's administration, while at the same time the Prime Minister made no secret of his hostility to the ten hours movement. No section of the operatives had ever proposed to impose this exceptional restriction upon the work of adult women, and it was stated during the debates in Parliament that not a single petition had been presented in favour of it. The battle in favour of shorter hours of work in factories had hitherto been fought exclusively on behalf of children and "young persons," and a "young person" was legally defined to be a person of either sex under eighteen years of age. The Select Committee of the House of Commons, it is true, recommended that the age of a female "young person" should be extended to twenty-one, but they went no further. The inspectors of factories, however, who had now got fairly to work in the manufacturing districts, very generally recommended the application of a restriction on the hours of work of all women.

Less importance would appear to have been attached to the suggestion then than now. The operatives aimed at the single determination to obtain a Ten Hours Act, and not a few of them were sanguine enough to look for a restriction on the motive power. This would have placed a restriction on the hours of work of both adult men and women; but the agitation in favour of this proposal was regarded as impracticable by the majority of the leaders of the short time movement, and it did not receive much encouragement in Parliament.

Manufacturers and employers, no doubt, looked with some indifference upon the proposal to include adult women from the fact that practically a restriction on the hours of work upon children and young persons in a textile factory is a restriction upon all who are employed. The conditions of labour in a factory are such that one section of the workpeople cannot be profitably employed without the other, and a limitation upon one section proves a restriction on the whole.

It is probable that the source of much of the agitation which has recently arisen over this question about the restriction of the hours of work of adult women may be traced to the fact that in subsequent extensions of the factory regulations to miscellaneous trades and occupations, this special feature of factory labour was lost sight of. When the hours of work in occupations in which adult women were mainly or exclusively employed came to be limited, a sharpness was given to the contrast between the restrictions imposed upon them and the freedom enjoyed by adult men which did not previously exist. In the Factory Act, 1878, this is to some extent recognised, and the hours of work in workshops in which adult women only are employed are subject to fewer restrictions than when they work in conjunction with children and young persons. Be the cause, however, what it may, it is a singular fact that what is now regarded by many as the most galling and the most unnecessary of the existing restrictions upon labour in this country was imposed voluntarily by Sir Robert Peel's administration in 1844. The women themselves never appear to have asked for it; and the employers were indifferent, for the reason that the restrictions imposed upon young persons and children practically applied to all the workpeople they employed, of whatever age or sex.

There was much justice in Sir James Graham's complaint of the futility of the educational clauses of the Factory Act. Anybody was understood to be qualified to act as a factory schoolmaster in those days. If an operative lost his arm or his leg by accident, the chances were that if there was a vacancy he would be promoted to be schoolmaster, as the most convenient mode of providing for him. The Home Secretary did his best to reform this scandal, but the "religious difficulty" proved too much for him. At least another generation had to pass away before public opinion proved strong enough to dispose of it.

The authority placed in the hands of the inspector of factories with respect to the schools served the purpose of checking the worst abuses; and it is to the great success which attended the enforcement of the compulsory half-time attendance under the Factory Act of 1844 that we attribute the rapid conversion of public opinion to the principle of compulsory elementary instruction for all children in the country.

The Government found itself beset with many difficulties as it proceeded with the new Factory Bill. The friends of the ten hours movement were very active and persevering. The Bill was read a second time on the 12th of February, and it came on for consideration in Committee on the 15th. On this occasion Lord Ashley proposed an amendment upon the second clause of the Bill, the practical effect of which was to limit the hours of work to ten per day. It forbade all employment in a factory from six o'clock in the evening till six o'clock the following morning. The amendment was resisted by Sir James Graham on behalf of the Government, and he was followed on the same side by Mr. Bright, who delivered a speech upon this occasion which has since been frequently quoted against him. The keenness with which Mr. Bright criticised the agitation in favour of the Ten Hours Bill provoked a painful scene between Lord Ashley and himself. Mr. Bright complained of the gross exaggerations which had been published and circulated relative to the treatment of factory children, and Lord Ashley resented the insinuation that he had lent himself to the encouragement of anything of this kind. A mutual explanation followed, however, and the debate was adjourned till the 18th. The Committee first divided on the proposal of the Government that the definition of the word "night" should be between eight in the evening and six in the morning; and on the question being put that the word "eight" stand part of the clause, the numbers were—ayes, 170; noes, 179: majority, 9. When the insertion of the word "six" was proposed, the numbers were—ayes, 161; noes, 153: majority, 8. Practically this amounted to a defeat of the Government and to the adoption by a majority of the ten hours clause. On Thursday, when the consideration of the Bill in Committee was resumed, the House divided on the proposal to fill up the blank in the Bill respecting the hours of labour by the word "twelve;" the Government sustained another defeat, the numbers being—for the number "twelve," 183; against it, 186: majority, 3. The Committee again divided on the proposal to fill up the blank with the word "ten," which proposal was in its turn defeated by a majority of 188 to 181, some members of the House being in favour of a compromise of eleven hours.

The House having thus refused to sanction either a twelve or a ten hours Bill, the Home Secretary suggested that the Committee should report progress, so as to give time to the Government to consider their position. The subject was again under discussion on the 25th and the 29th, and ultimately the Government resolved to withdraw the Bill with the view of re-introducing it in an amended form.

COTTON.—XXI.

CALICO BLEACHING—TURKEY RED DYEING.

By David Bremner, Author of "The Industries of Scotland."

When a web of calico is removed from the loom it is of a dirty grey colour, arising from the warp-dressing, oil stains, and impure fibres of cotton. It is therefore necessary, before sending it to the market for consumers, that it should be bleached and made more presentable to the eye. For this purpose it is transferred to the bleachers, whose occupation forms a distinct branch of the cotton manufacture. Many of the bleach-works are of great extent, and are fitted with machinery

capable of performing a variety of operations, which in the early days of the trade were done by hand. An abundant supply of pure water is an essential to the carrying on of a bleach-work, and the sites of such establishments have been chosen in localities where the fluid could be obtained in sufficient quantity. Up till past the middle of last century bleaching was conducted in a crude and tedious manner. We read that it consisted of steeping the cloth in alkaline lyes for several days, washing it clean, and spreading it upon the grass for some weeks. The steeping in alkaline lyes, called "bucking," and the bleaching on the grass, called "crofting," were repeated alternately five or six times. The cloth was then steeped for some days in sour milk, washed clean, and crofted. These processes were also repeated, diminishing every time the strength of the alkaline lye till the cloth had attained the requisite whiteness. A great improvement on this method was effected by Dr. Home, of Edinburgh, who employed water acidulated with sulphuric acid as a substitute for sour milk, and so was able to produce effects in a few hours which by the old process required weeks. The discovery of chlorine by Scheele, and its application to the bleaching of cloth by Berthollet in 1785, marked another great advance in the art; and further improvements were also effected by Mr. Henry, of Manchester, and Mr. Tennant, of Glasgow, who almost simultaneously discovered that by combining chlorine with a solution of lime its very objectionable odour might be got rid of.

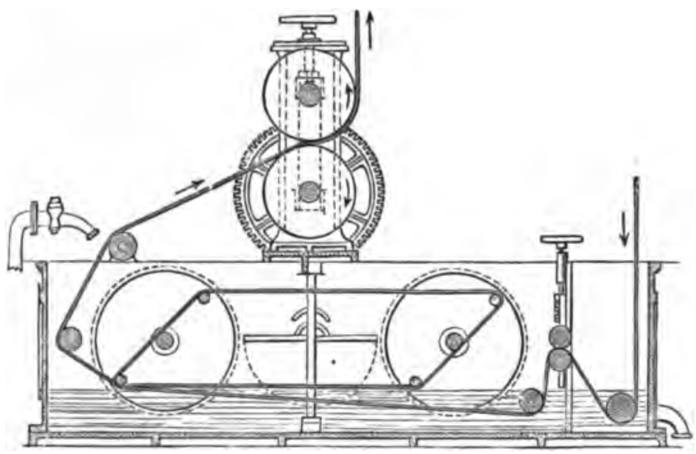


Fig. 1.—Bridson's Washing Machine.

With a view to removing the loose and protruding fibres from its surface, the calico to be bleached is first singed, by being passed rapidly over a metallic plate heated to a high degree or drawn through a gas flame. In works in which bleaching is carried on upon a large scale it is usual to unite two or three thousand pieces of cloth, each about twenty-five yards in length, in a continuous web by sewing them together. By this arrangement a great saving of handling is effected, and as the line of cloth passes through the works it is subjected to a succession of operations. The first of these is thorough washing in cold water, which removes a great part of the warp-dressing, and also the carbonised particles left by the singeing machine. The washing is done by passing the cloth through a trough and over a system of rollers. Every part of the cloth is plunged into the water and wrung nearly dry a dozen times in the passage through the machine. Some washing machines are capable of disposing of about 30,000 yards of cloth in an hour, the consumption of water during that time being 30,000 gallons, or at the rate of one gallon for each yard of cloth. As the washing proceeds the water is constantly undergoing renewal by the outflow and inflow pipes being kept open (Fig. 1).

Bleachers have their individual ideas as to the best mode of treating the cloth entrusted to them, and consequently the processes conducted in different establishments vary somewhat. About forty years ago, when bleaching was brought to what was considered perfection, it was, according to Mr. Baines, conducted as follows:—After the first washing the cloth was placed in a "kier," or cylindrical boiler, covered with a closely-fitting lid, and having a false bottom perforated with holes. Cream of lime was poured on the successive layers of cloth, one pound weight of lime being used to each 35 lbs. of cloth. The "kier" was so contrived that a stand-pipe in its centre poured upon the cloth a constant stream of the liquid from radiating apertures at its upper end. As the liquid percolated through the material, it loosened and carried off impurities, and on reaching the bottom of the boiler was again, by the pressure of the steam, forced up the pipe, and so on to the cloth again. To this operation the cloth was subjected for eight hours, after which it had to go through another thorough washing. A bleaching liquor, composed of chloride of lime and water, having been prepared, the cloth was next placed in that and allowed to steep for six hours. On removal from the bleaching

cistern it received another washing, and was then ready for the "souring" process. The souring liquor was composed of sulphuric acid and water, in the proportion of eight gallons of the former to 200 gallons of the latter. The effect of this treatment was to remove the oxide of iron which in the course of the operation had been deposited on the cloth, giving it a yellowish hue, and also the lime which it had imbibed. Another washing in cold water followed, and then the cloth was boiled for eight hours in an alkaline lye, composed of 64 lbs. of carbonate of soda to 2,100 lbs. of cloth. A second steeping for five or six hours in bleaching liquor, somewhat weaker than the first, and a second bath of souring liquor, followed by washing in cold water, completed the bleaching process. This is, in the main, the course of procedure still employed, though, as already stated, most bleachers make variations in the details.

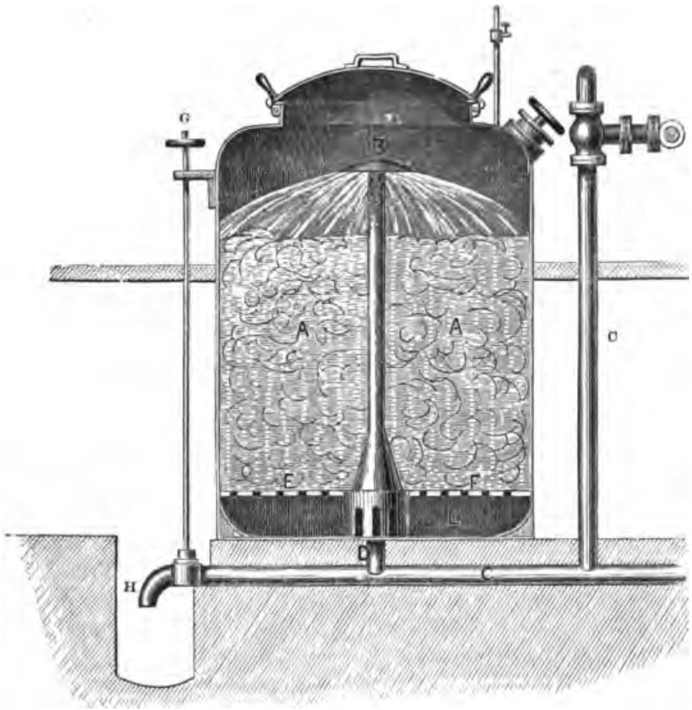


Fig. 2.—Mather and Platt's Kier.

(A A) Calico coiled in Interior of Vessel; (B) Stand-pipe with Umbrella Top; (C C) Pipe conveying Steam and Liquor into lower part of Kier (E) through branch D; (F F) False Bottom perforated for Flow of Liquor; (H) Outlet for Exhausted Liquor opened by Screw-valve and Rod, G.

Here is a summary of the seventeen processes in bleaching, as carried out at one of the leading bleach-works in Lancashire:—1. The pieces sewn into lengths for convenience of treatment. 2. Passed through the singeing apparatus. 3. Boiled in a kier for fourteen hours in a solution of caustic lime. 4. Washed. 5. Soured in the washing machine with hydrochloric acid. 6. Boiled for sixteen hours in a solution of soda-ash and resin. 7. Washed. 8. Passed through a bath of chloride of lime, or "chemicked," for one or two hours. 9. Washed. 10. Boiled for five hours in a solution of carbonate of soda crystals. 11. Washed. 12. Put into chloride of lime as before. 13. Soured in hydrochloric acid. 14. Deposited on "stillages," or low grated platforms, for six hours. 15. Washed. 16. Squeezed between rollers. 17. Dried, by being passed over tin cylinders heated by steam. These operations usually occupy five days.

Many attempts have been made to improve the "kiers," so as to quicken the boiling process, and several varieties are now in use. Messrs. Mather and Platt, of Manchester, are the inventors of one of these which has come into much favour. It consists of an iron cylinder with false bottom, and steam pipes for heating the solution and driving it through the cloth. In the centre is a stand-pipe, with an "umbrella" jet at its upper end, and when the steam is up the liquid is squirted over the cloth from this jet, and as it percolates to the bottom of the kier is again forced up the pipe. A closely-fitting lid conserves the heat. This kier, with its system of pipes, is shown in Fig. 2. In some establishments high-pressure kiers are used. These are made of boiler-plates, and arranged in pairs, and the means provided for circulating the bleaching fluid are more complicated than in the apparatus just described. The desired result is, however, more speedily accomplished by the use of high-pressure steam.

If the cloth is not intended to be printed or dyed, it is, on the completion of the bleaching operations, sized, calendered, and folded for the market. The practice of sizing has already been dealt with. It originated in a desire to make all cloth, even that of poor quality, look well to the eye, but it was not long in suggesting to unscrupulous minds a mode of defrauding the public. At first it was thought sufficient to run the cloth through a bath of thin starch, but to that came to be added porcelain clay and calcined sulphate of lime. After being sized, the cloth is dried, by

being passed over a series of heated copper cylinders. It is then ready for calendering, by which operation its surface is glazed, or otherwise "finished," according to the purpose for which it is intended. On leaving the calender, the cloth is folded and measured by a machine of simple construction.

A large proportion of the calico and yarn exported is dyed red, and much of the cloth printed is first treated with that colour. The mode of dyeing practised until quite recently was derived from the Turks, and the colour was known as "Turkey red." It was introduced into England, nearly a century ago, by M. Borelli, a Frenchman, who established himself at Manchester, and was rewarded by the Government for the disclosure of the secrets of the process. A year or two later another Frenchman, M. Papillon, in conjunction with Mr. George Macintosh, founded a Turkey red dye-work in Glasgow, and that town became famous for this branch of business. Up till the year 1810, however, the colour could be imparted only to thread and yarn. In that year M. Kœchlin, of Mulhausen, in Alsace, discovered a method of giving the colour to cloth, and a year afterwards invented one of the most beautiful and interesting processes in calico printing—namely, the mode of discharging the colour from the dyed cloth, according to any pattern desired, and inserting designs in other colours. The latter consists of printing upon Turkey red or any dyed colour some powerful acid, and then immersing the cloth in a solution of chloride of lime. Neither of these agents singly affects the colour, but those parts which have received the acid, on being plunged into chloride of lime, are speedily deprived of their dye, and made white by the action of the liberated chlorine.

Yarn and calico intended to be dyed are treated to a succession of scourings and boilings, such as already described in the case of plain cloth; but before being ready for the dye-vat they have to undergo further treatment of a special character, the object of which is to soften and open up the fibre, and make it susceptible to the action of the dyeing materials. The preparatory operations are nearly thirty in number, and consist of a succession of steepings in various liquors. The first of these is known as "the soap steep," without which the dye cannot be produced in new cloth. The ingredients of the soap steep are one gallon of Gallipoli oil, one and a half gallons of soft sheep's dung, four gallons of solution of carbonate of soda of the specific gravity 1·06, one gallon of solution of pearl-ash of the specific gravity 1·04, mixed with a sufficient quantity of water to make up twenty-two gallons. This liquor is milk-white, and is, in fact, a kind of incipient soap. It is mixed in a large tub, and agitated by levers radiating from an upright axle. The ingredients having been thoroughly blended, the liquor is drawn off to the padding machine — a vat with mechanical arrangements for moving the cloth about so as to ensure its complete saturation. On being removed from the padding machine, the cloth is dried, either in the open air or in a stove. It is again put through the padding machine, and again dried; and sometimes these operations are subsequently repeated once or twice, the object being to ensure the thorough impregnation of the fibre with liquid, as experience has shown that by this means alone can the best results be obtained in the dye-vat. A bath in a weak solution of pearl-ash follows. A liquor, composed of certain proportions of Gallipoli oil, soda lye, and caustic potash lye, is now prepared, and into this the cloth is placed, the aid of the padding machine being again called in. This operation is repeated three or more times, the cloth being dried between each wetting. It is now desirable to get rid of the oil in the cloth, and this is accomplished by washing it well in a lye of pearl-ash and soda. A decoction of nutgalls or sumach is next applied to the cloth, its effect being to ensure an equality of shade when the cloth comes to be fully dyed. From this decoction the cloth derives a yellow tinge, and it is believed that this has the effect of rendering the red more lively. After being dried the cloth is ready to receive the mordant, which is a solution of common alum or of acetate of alumina, and its effect is to keep the colour "fast." The dye-vats are of metal, and are fitted with steam pipes, so that the liquor can be raised to any desired temperature. The vats are oblong in shape, and each has a skeleton drum revolving in it, on which the cloth is wound and kept continuously moving through the dye. When the cloth is put in, the dye is cold, but steam is gradually admitted to the pipes until, in the course of an hour, the boiling point is reached. On being dried at this stage, the cloth is seen to be of a dirty brownish-red colour, and it has to be subjected to the "clearing" process before its beauty is revealed. This process consists of boiling the cloth for twelve or fourteen hours in a mixture of five pounds of soda, eight pounds of soap, and sixteen to eighteen gallons of the lye used before the galling process. Twenty-five pounds weight of cloth are usually allotted to each dye-vat, and four

of these quantities are put into the clearing-boiler at a time. A second operation of the clearing process is to boil the cloth in a high-pressure boiler, in a liquor composed of four or five pounds of soap and from sixteen to eighteen ounces of protochloride of tin dissolved in water. The use of the salt of tin is to give a shade of scarlet to the cloth. The oxide of tin seems to combine with the oleaginous acid of the soap, and this insoluble soap unites with the red colouring matter of the madder fixed upon the cloth, and improves the shade of colour. This completes the processes of dyeing, which, it will be seen, are somewhat tedious.

The arts of the dyer and the calico-printer are founded on the proper understanding and use of "mordants," or biting substances. In the case before us the cloth has the property of decomposing the salt of alumina, and of combining with and retaining a portion of alumina. The red colouring principle of the madder in which the cloth is subsequently immersed has an affinity for the alumina, and combines with it. The consequence is that the alumina being firmly retained by the cloth, and the colouring matter by the alumina, the dye becomes "fast"—that is, it cannot be removed by water, even when soap is added, though water alone is sufficient to remove the red colouring matter from the cloth if the alum mordant has not been previously applied. With an iron mordant, madder produces a purple colour, and with alum and iron in certain proportions it produces chocolate or black.

Madder has done good service in its time, but, like many other things that were once indispensable, it has had to give way before a product of modern science, and is now rapidly going out of use. In 1870 our annual import of madder and madder-roots amounted to 15,000 tons; now only a fraction of that quantity is taken by our dyers. Madder, it may be stated here, is the product of the roots of the *Rubia tinctorum* and allied species, which grow in various parts of the south of Europe and in India and Ceylon. The plant used to be extensively cultivated in Afghanistan, and is one of the leading products of Beloochistan. In the early days of the Turkey red dyeing trade in this country the madder was imported in a dried and ground state, but in later years its valuable properties have been extracted and concentrated to some extent in the countries where it is grown. When prepared in this way, the stuff is known as "garancine." In the dye-vat a certain proportion of bullock's blood is added to the madder. There are two colouring matters in madder: one, which is yellow, is soluble in cold water; and the other, which gives the red, is soluble only in boiling water. The yellow matter is known as xanthin, and the red as alizarin. As the presence of the former would have a depreciatory effect upon the colour of the cloth, it is always got rid of by a preparatory process.

The discovery which led to the deposition of madder from the important place it held so long among dye-stuffs was that alizarin, its most valuable ingredient, could be obtained artificially from anthracene, one of the heavy products of coal-tar distillation, and that at a cost far below the price of garancine. From 65s. per cwt., madder fell, in the course of a few years, to 15s., and now the price obtained for it is so low that its cultivation will probably be entirely abandoned. Of alizarin, an authority on dyeing said in 1876:—"So cleanly and convenient is this new dye-stuff in its application that, even at an equal price for an equal quantity of colouring matter, madder would not be bought. Many styles not capable of being done with madder have been introduced, especially imitation of Turkey red with aniline black freely introduced, where the shade of red so closely resembles Turkey red, and is so much more quickly and cheaply produced, that it is questionable whether this celebrated dye will not before very long become a thing of the past. Many varieties of artificial alizarin are now made, varying from almost pure alizarin to those dyeing very yellow shades of red." Since this was written further progress has been made, and the prediction of the writer seems to be on the high way to fulfilment.

INDUSTRIAL ART.—V.

THE ARTISTIC USE OF METALS: IRON AND STEEL.—SECOND PAPER.

BY JOHN FORBES-ROBERTSON, AUTHOR OF "THE GREAT PAINTERS OF CHRISTENDOM."

BEFORE proceeding to give further examples of iron-work in its architectural relations, such as in gates, railings, and the like, it may not be thought altogether out of place, if reference for a moment be made to iron and steel work of a more intimately domestic kind.

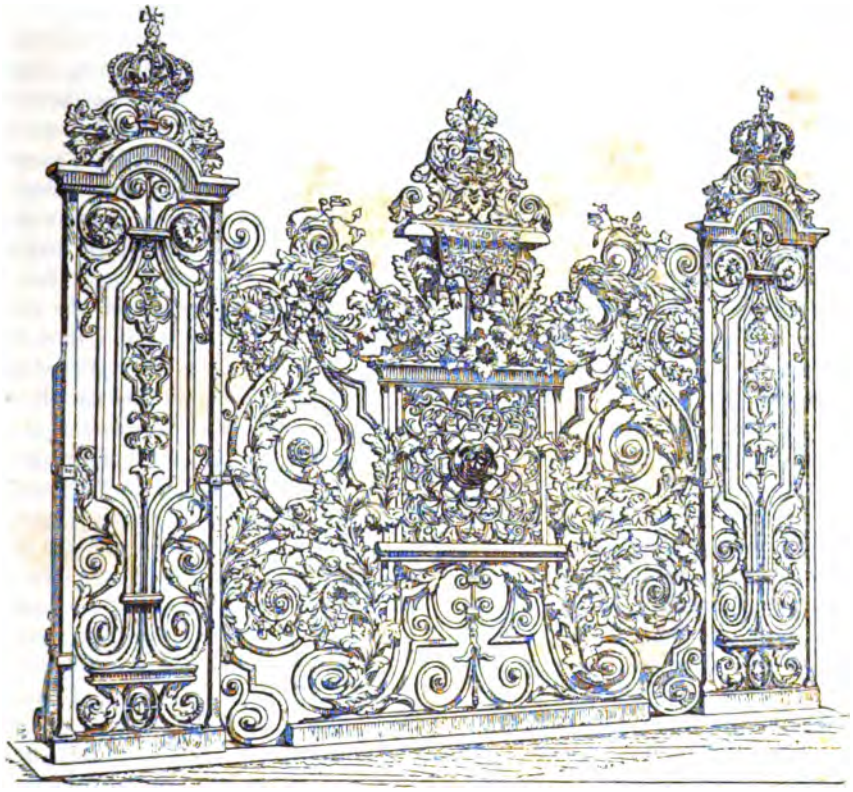
In mediæval times, hinges, handles, locks of cabinets and family chests, knockers and door furniture generally, chandeliers and lamps—the last-named being specially dear to the designing genius of the antique world—were frequently the subjects on which smiths exercised their cunning, a cunning often guided by the great art-masters of the period. Leonardo da Vinci, Raphael, and Michael Angelo, Dürer and Holbein thought it not beneath the dignity of their art to make familiar objects minister to our sense of what is æsthetically grateful.

"All that human hands created," to quote the words used by Dr. Alfred Woltmann on this subject, "they wished to see beautiful, whatever purpose it served, and to whatever art it belonged, and they found for everything the appropriate form. If they built stately palaces, in whose cheerful and festive splendour all the luxuriance of the Renaissance style appeared, they were not merely careful about the architectural part alone, but they sent for other artists and artisans to provide for the rest—nay, all that tended to ornament and decoration was devised in their own spirit: the iron grating of the portals, the paintings on the walls, the stucco work of the ceilings, and even the furniture, the tapestries and the utensils." Towards the close of the Middle Ages, indeed, and especially during the first outburst of the intellectual revolution so familiar to us under the name of the "Renaissance," the activities of Western Europe, from many moving whys and wherefores, were keenly tempered and artistically aspiring. The quickening impulse, which spread from land to land, like a spiritual epidemic, and whose first joyous recipients were those whose natural habits of mind belonged to the morally apostolic, soon reached the class beneath them; and handicraftsmen shared the enthusiasm of those creative geniuses who had first stirred in their souls the dormant sense of the fit and the beautiful. The functions of the artist and of the artisan were, as has been implied, so dovetailed, so mutually interpenetrating and interlaced, that it became difficult to say where the creative purpose of the one ended, and the cunning craftsmanship of the other began. It was so in France and in the Low Countries, in Albert Dürer's Nuremberg, in Augsburg, the city of the Fuggers, and in several other commercial centres of Germany—not to mention Venice and her sister cities, so rich in fine examples; and the most active period of iron industry and of metallic design in our modern sense, and apart from Gothic practice, lay, whether here or on the Continent, between the last quarter of the sixteenth and the last quarter of the eighteenth century. The work of the mediæval smith was always simple, direct, and independent; and it was not till the spirit of revived letters and re-awakened art had swept over Western Europe that he began to follow loyally the lead of the architect, and make his own work subservient to the leading idea expressed by the designer. The smith was perhaps the last man to feel the quickening glow of the Renaissance; but once it reached his soul, its influence became, as we have seen, very great, and continued active for a century and more after architecture and painting had expended their force, and had ceased for a time to show symptoms of vitality. For this reason, perhaps, some of our best examples of iron-work belong to the seventeenth and eighteenth centuries.

Such noble co-partnery as that to which we have alluded has long been unknown in these lands; but now that the controllers of our great industries have answered with glad intelligent shouts the voices of those so long crying in the wilderness of prejudice and ignorance to prepare a way, that the inane, the incongruous, and the ugly might be swept from our sight, we are in full hope that the whole region of man's objective activity will yet blossom as the rose. The advancement of civilisation—and the cultivation of the art-instinct is one of its most moving factors—is not so much the privilege of one section of society as the business and duty of the whole harmoniously co-operating community.

Beginning, then, with our fire-places, which,

doubtless, as invention extends, will require a new modification of art principles—if the hearth itself, which comes to us with associations which a Promethean antiquity has sanctified, be not swept out of existence—we would ask, Are our ordinary fire-irons what they might be? When wood was the fuel burnt on the hearth, the instrument equivalent to our modern poker frequently ended in a hook, so that it might be used in lifting the heavier logs; and the tongs, in like manner, often ended in a mediæval lady the tongs had only to grip a light piece of half-burned wood; but in these days, if one has to seize a piece of coal, especially if of any appreciable weight, the tongs fails to grip, because the hand is so far from the pincers; and, if the hand is muscularly weak, a noisy catastrophe at the fire-side is the result. In certain country districts where large lumps of coal are used, the ponderous form of the tongs must, we suspect, remain; but in great cities a lighter and a shorter



Wrought Iron Screen by Huntington Shaw.

pair of hooks, that it might lift the smaller pieces of wood as well as grip them; and for the sake of uniformity, if not from some religious symbolism, the three domestic ministers of the hearth, the poker, shovel, and tongs, were of equal length, at least, in their ornamental guise. This fashion of equality in size we have kept up for three centuries, although instead of burning light wood, we now burn heavy coal. Against the length of the poker we have nothing to say—the necessity of leverage settles the question; but it is very different with the tongs; its very length, on the other hand, prevents its effective use, the mechanical conditions being different. In the hands of the instrument is preferable, care always being taken that the balance and ornamentation of the handle are consistent with common sense. A modern tongs of the conventional height, looking at it in connection with the purpose for which it was made, is one of the ugliest things in the whole category of domestic appliances,—which is saying a good deal. We would prefer doing away with the hinge altogether, and falling back upon the old bow-spring handle.

Moreover, the ornamental shovel, also, is to be condemned much on the same principles, namely, that its handle is by far too long. It requires a steady nerve, vigorous muscle, and much practice to

convey one of those long shovels, full of coals, from the coal-scuttle to the fire, simply because the centre of gravity in the loaded shovel is too high, and the hand has to struggle against its perpetual tendency to topple over.

But in trying after fresh forms in which use and ornament shall be sensibly combined, we must be careful not hastily to abandon the old. All of us have more or less to defer to fashion, and to this fact have we to attribute the loss or disuse of many a becoming shape in our domestic appliances. We have spoken of the poker, the shovel, and tongs; let us turn for a moment to their neighbour, the coal-scuttle. Of late this article has assumed all sorts of disguises, mainly in the box direction. First of all, it is a puzzle to a stranger as to its use; secondly, as to its material; and thirdly, when you are told what the highly japanned or painted thing really is, and are asked to put some coals on the fire, you marvel how it is to be opened. Fourthly and lastly, having discovered the shovel peculiar to this highly-decorated cabinet or "vase," as the case may be, you rumble about in its dark unseen depths for coals which refuse to be charmed from their hiding-place. The thing is probably nearly empty, and consequently the muscular jerks and struggles of your hand are all in vain. Its nerves begin to send messages to the brain so fast and furious that the authorities there have lost all power of pronouncing whether you have secured a shovelful of coals or not; and your hand having thus lost, as we should say, its nicety of touch and sense of weight—for you have no aid from the eyes—you rise from your stooping position irritated, baffled, and befooled; when you look down at the shovel and discover that what you thought was a goodly quantity of replenishing fuel, turns out, as likely as not, to be three little insignificant bits of nubbly coal no bigger than hazel-nuts.

Now, go back to the good old-fashioned copper coal-scuttle, with its beautiful contour of helmet-like sweep, bright and shining in its natural corner, as if ready to cry out, the moment the word "coals" is mentioned, "Here you are!" There is no finding and opening of lids, and then groping for what may or may not be within. All such complex action is avoided. And whenever the shovel refuses to do its functions from the perversity of the coals themselves, as will happen—to use a well-worn colloquialism—in the best-regulated families, the voice of the copper coal-scuttle is once more heard with its cheery "Here you are!" and you at once take it up bodily by its two handles, and, by one of the most graceful actions to which the human frame can submit itself, you toss the necessary amount of coal upon the grateful fire. The modern coal-scuttle, in short, is one of those cases which illustrate the tendency of fashionable attempts at artistic reform to degenerate into æsthetic nonsense. Much better go back to the old lines of the copper or brass coal-scuttle we have indicated, and improve upon them. There is no occasion for covering up or concealing what we burn. We need not fear dust, for parlour coals are now what the trade calls "screened."

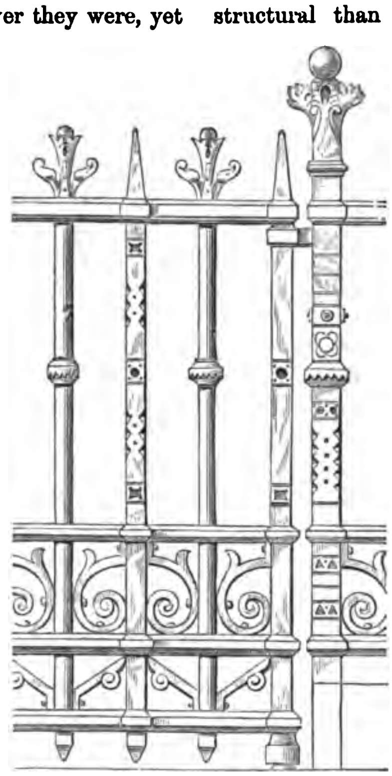
As to fire-places themselves, there has been really so much done of late for their improvement, and science as well as art has been so universally called into play, that scarcely a suggestion in the way of advantageous change offers itself. The time has gone by when the grate was perched up a couple of feet above the hearth, and was of such a shape that it required a great fire to warm *it*, instead of a little fire to heat the room. So long as the fire-grate is kept on a level with the floor, or nearly so, and the flame-producing air allowed to come from a hollow underneath, the character of the fender and the decoration of the fire-place generally will almost come of themselves. As the great canopied fire-places of the sixteenth and seventeenth centuries are no longer in vogue or required, the ornamentation of the hearth and its belongings will necessarily be quiet and subdued, and always with a structural reference; but not on that account bald, cheerless, and uninviting.

At the beginning of the century steel watch-chains, shoe-buckles, and metal buttons, were the prevailing mode; but the steel toy trade of Birmingham vanished with the advent of peace and the fall of the great Napoleon. To what perfection the art had attained may be guessed when we say that a steel watch-chain of the finest workmanship sometimes cost as much as eighty pounds. One regrets that change of fashion should have given the quietus to so cunning a craft.

An industry more precious still was certainly practised in England during the sixteenth century. We allude to the art of damascening. Robert Dudley, Earl of Leicester, had a beautifully damascened box of English workmanship inlaid with his own armorials, which is still extant. The art seems to have disappeared from Western Europe, although it still lingers in the region of its early Moorish home, and a damascened vase, cabinet, or sword-blade can still be furnished to the wealthy connoisseur by Zulago of Toledo.

It is rather humiliating to think that we in this country have no native artists who can produce a satisfactory piece of *repoussé* work. We have not now shields and swords, helmets and breastplates, on which to exercise the skill of the artist—and sometimes *repoussé* work, chasing, and damascening all appeared in the same piece of armour; but we have safes, and cabinets, and caskets, which are as susceptible of art treatment as ever they were, yet for examples of these we have invariably to go to a foreign source.

On approaching a house the first indication of hospitable possibilities within is the inviting door-knocker. To the iron flambeau extinguishers which still linger on either side the door railings in such neighbourhoods as Bloomsbury, London, we need not allude, as with the advent of gas their functions ceased; but the knocker is still a familiar institution in full activity. In it we have an object which lends itself most readily to art, and the shapes which it may assume, and still be interesting to look upon, are almost endless. Its capacity in this respect is absolutely Protean. The bronze knockers of Venice and the wrought-iron knockers of Nuremberg were as artistic in their treatment as they were varied; and there is nothing to prevent our manufacturers from making the knocker as delightful a feature as ever it was, provided the artist in his design does not violate the idea of association. In this respect we are glad to see our manufacturers are wisely reproducing some of the best examples of mediæval knockers, as exhibited at South Kensington Museum and elsewhere.



Design for Iron Railings (Macfarlane's Casting).

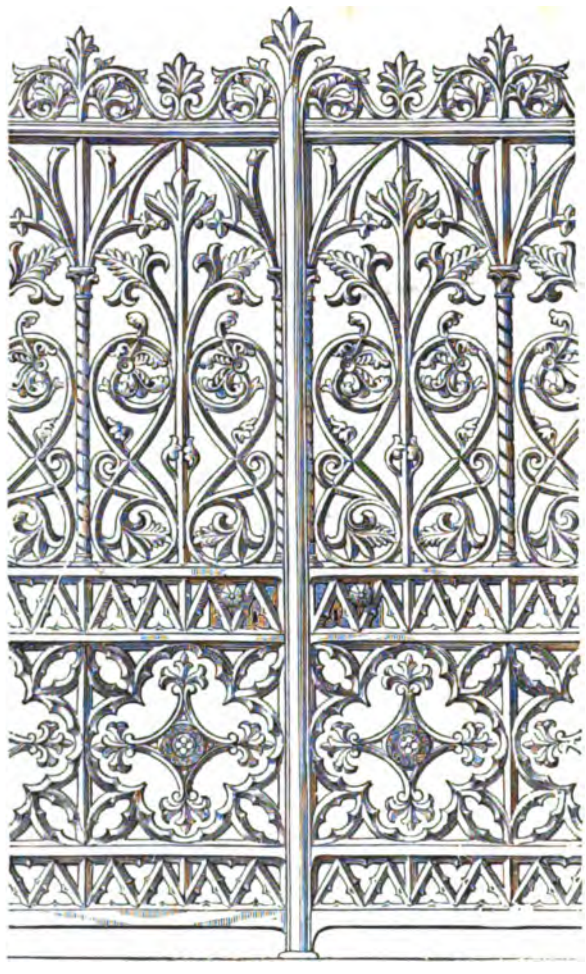
Another object, whose mediæval shape they are wise in imitating, is the key, whether of the street-door or of my lady's cabinet. Every one must have noticed how easily the bow is bent, and how useless the key becomes if, as is often the case, the bow is broken. Now, by filling up this bow with open figure or fretwork, as the old key-makers did, they not only made it the means of conveying art ideas, but the pleasing grotesqueries which they introduced absolutely strengthened the key itself. Here again the Messrs. Hart are doing the public good service by their antique revivals of keys, locks, hinges, door-plates, knockers, and the like.

But, how much soever we may by skill and labour force iron or steel into artistic forms,—and there are many cases, as we have shown, in which artistic manipulation is a thing much to be desired, —we must never forget that iron after all is more a structural than a decorative metal. Once the popular mind is disabused of the idea that it is the material and not the art displayed upon it that is the precious thing, we may find iron and steel entering much more largely into the region of what we call objective æsthetics; in the meantime we must find what is beautiful in iron-work mainly in its structural aspects. We therefore submit to our readers examples of railwork, one (p. 41) a wrought-iron screen from Hampton Court Palace, now in Kensington Museum, by the famous Huntington Shaw, blacksmith of Nottingham, who fashioned it about 1695; the others (pp. 43-4) modern cast-iron rails or gates by Macfarlane of Glasgow.

The original number of screens was twelve, and some of them are on loan at South Kensington and others at Bethnal Green. Each screen is about thirteen feet wide, and eleven feet high, and one pattern pervades the whole. The centre square, however, in three of them at least, is richer in detail than in the others. The example before us, for instance, shows the English rose (see Fig., p. 41); in another we have the Scottish thistle, and in a third the Irish harp. "All the details," says Mr. W. Penstone, in his admirable "Remarks on Smiths' Work," "are most wonderfully wrought out, the small rosebuds and sprays being represented with great fidelity to nature, as if in emulation of the works of Grinling Gibbons in wood. A naturalistic treatment, however suitable for the material in which this latter artist chiefly worked, is not at all so for iron. The ornament is almost entirely of an *appliqué* character; the larger scroll-ends are even cased in sheet iron. It is very surprising that, notwithstanding the care displayed

in the formation of these details, the whole is very badly put together, and it is no wonder that the influence of time and weather was speedily bringing these fine works of art to ruin. Very few of the scrolls or stems are welded at their junctions, but simply united by iron tongues and pins, the heavy strains on which have in some instances caused them to give way. The leafage also, which in the most ordinary gate-work of this period was always welded to the stems from which they spring, are here merely riveted or screwed—the larger branches in several pieces. Notwithstanding such defects, however, these works must always be objects of admiration, from the boldness and originality of their design, and the evidence of patient skill in their production." The gates in the Apollo Gallery of the Louvre belong to the previous century, and are, perhaps, purer in taste and more classically severe in general treatment; but we must not refuse the quality of impressiveness and appropriateness to the free, florid style of the English smith. The bronze enclosure to Henry VII.'s tomb at Westminster, and the railing to Edward IV.'s tomb at St. George's, Windsor, are, each in its way, unequalled marvels of design and workmanship. Both are probably the work of foreigners; the latter, as our readers are aware, being popularly ascribed to Quentin Matsys.

The other wood-cuts (pp.43-4) show the present state of cast-iron work—an industry, in its art-aspect at least, which has come into existence within our own time. The best work of Durenne, Barbizat, and the other eminent French iron-moulders—not to mention Hoole of Sheffield, Handyside of Derby, the Coalbrookdale Company, the Harts of Birmingham, and Walter Macfarlane of Glasgow, to whom artistic iron-casting has been a life's devotion and delight,—has all been done within the last thirty or forty years.



Design for Iron Gate (Macfarlane's Casting).

The Macfarlane rail is remarkable for the cleanness of its casting; there is not the faintest hint of "gumminess"—all is sharp and fresh and iron-like, and to this last-named quality we attach the greatest importance. The natural structural arrangement belonging to an open enclosure is strictly adhered to; mental association is preserved and satisfied, and the idea of rigidity and stability is conveyed at once to the eyes, and not left to the slower process of ratiocination. It is not the province of art to conceal, but rather to emphasise what is constructive, provided always it be done soothingly. In other words, an object ought not only to *be* what it pretends, but to *look* it.

We have also in this rail (p. 43) an illustration of variety in unity—the round iron upright, rising from its substantial basis of strong double horizontal bars, with its scroll-filled interstices, alternating with a cleanly cut square one, each with its appropriate terminal—a novelty reminding one of Raphael, when he varied in a similar way the architectural headings of the windows in the first Roman palace he designed. Both in the Macfarlane gate (p. 44) and in the railing there is a sense of artistic moderation and restraint, which speaks well for the designer; we are freed from all apprehension of his lapsing into anything approaching vulgarity, and his work carries with it a feeling of refinement and dignity.

In small, hand-wrought, ornamental grilles, especially when the bars or rods are diagonally arranged so as to form diamond-shaped interstices, a once fashionable and still very charming Venetian pattern might be revived. Its merit lay in the manner in which the *fleur de lis* at geometric intervals formed, floried and counter-floried, the decorative tie at the intersection of the rods or bars. With a slight modification Mr. Macfarlane, with his appliances, might adapt this pattern—and it is only one of thousands—successfully to the sand-mould.

But besides grilles, gates, and railings, there are many other works in iron, such as safes, deed-chests, railway-viaducts, and the like, to which the art-principles, which from time to time we have propounded in these chapters, are peculiarly applicable, and of which, had space permitted, we might have given examples; but we have said enough, we hope, to stimulate inquiry and promote experiment in the almost limitless field of industrial art.

It is to be regretted that the improved art quality of iron-work has not been accompanied by a like revival in the working of the so-called precious metals. Our gold and silversmiths are æsthetically behind the workers in iron, and rarely produce anything seriously worthy the attention of the critic—plenty of barbaric gold, but little of culture and educated taste. When any of our large houses do turn out a cup or vase, informed with beauty, endowed with objective thought, and crusted o'er with stories of the gods, the chances are—especially, as we have already seen, if it is a work in *repoussé*—all in favour of the supposition that the head that designed it, and the facile hand that wrought it, belonged to some naturally endowed, technically-trained Frenchman. Both in the Gothic period and all through the classic revival, the goldsmith followed, more or less closely, in the ornamentation of his casket, shrine, or reliquary, the architectural fashion of the time. A purer and more original art in the precious metals was practised previously to this by our Celtic neighbours; and it is matter of concern that the beautiful examples of Highland and Irish gold ornament which we possess are so few in number. Human greed and the accidents of a thousand years have gone hard with Celtic art. There is, indeed, no reason why work in gold and silver should not become sufficiently important in a commercial view to be classed among the great industries of the country; or why works in iron and steel should not be artistically as valuable as those fashioned in the rarer metals.

FOREIGN RIVALRIES.—X.

EARTHENWARE AND GLASS.

By H. R. Fox Bourne.

PLINY'S statement that the manufacture of glass was started by some Phœnician merchants who, cooking their food by the sea-shore, observed that the ashes of the plant with which they made a fire melted the sand and produced a transparent substance, is corrected by the researches of archæologists, who find that the art was practised by the Egyptians at a still earlier date. Yet older must have been the origin of the potter's craft. Every rude tribe of men, in its first movement towards civilisation, has moulded clay into convenient shapes and hardened it by baking, with the addition of such simple expedients as it could devise for preventing the vessels thus made from either crumbling away through lack of moisture or being again softened by the liquids placed in them. It is in the perfecting of such expedients, and in the adoption of other expedients for combining beauty with usefulness, that the real art of the potter consists. The materials out of which earthenware and, to a great extent, glass are made abound everywhere, and the conditions of rivalry between different nations in their manufacture depend almost exclusively on the grace and skill with which very cheap and commonplace ingredients are handled.

As regards both trades, whatever eminence Great Britain now possesses is of comparatively recent growth. The Chinese were famous potters more than four thousand years ago, and they seem to have worked on almost in their old lines, while Egyptian, Greek, and Roman rivals have sprung up and died out; and indeed all the successive developments of the art in modern Europe have only in some respects contrived to surpass them and their pupils in Japan. It is worth noting

that the revival of pottery in modern Europe, after the decay of Greek and Roman civilisation, is to be traced to the Mahometan religion, which cannot be credited with much other service to the progress of artistic refinement or peaceful occupations. The greater cleanliness of earthenware as compared with anything that could be made of wood or metal commended it to the devout observers of Islam ritual, and the dainty shapes and colourings which the Moors and Saracens imported into their work of this sort, induced the Italians to bring their majolica to the perfection it attained, and to employ Michael Angelo, and Raphael, and their great disciples to adorn it with exquisite drawings. When the majolica ware of Italy deteriorated, about the sixteenth century, the faïence of France and Holland and the stoneware of Germany took its place. Though England had maintained a certain reputation for its Staffordshire potteries during several hundred years before, the work turned out by it was only coarse and cheap—for use, not for ornament—until the German brothers Elers settled at Burslem in 1688, and gave a new turn to the business which, after a lapse of nearly a century, had Josiah Wedgwood for its great leader. Wedgwood's story is well known, and it is not necessary to recount the services that he, as an honest tradesman and an artist, rendered to his country. Very practical evidence of it is in the fact that the population of the Staffordshire district known as "the Potteries," which in 1801 was 23,626, had risen in 1871 to 187,225. The number of persons actually engaged in the district at that date in the earthenware trade was 34,651 out of the 45,122 so employed throughout the whole kingdom.

Wedgwood and his successors, the Spodes, the Masons, the Mintons, the Doultons, and others, have placed England in the foremost rank as a producer of nearly every kind of pottery. These enterprising and talented men have devoted themselves, with artistic tastes not often to be found in other classes of manufacturers, to the revival of everything that was good in the old ways of porcelain making, and to the development of new methods of workmanship and new varieties of ceramic ware. The reputation, however, which they have won for the country and themselves by their delicate and costly productions in porcelain, stoneware, faïence, terra-cotta, and mosaics, important and honourable as it is, is perhaps of less commercial value than the great revolution they have done so much to effect in the general character of their trade. Cottages can now be stocked with dishes, plates, and cups of a quality that only a few generations ago was not to be found in palaces, and, besides the abundance with which the demands for every sort of crockery are thus met, new tastes are aroused and satisfied by earthenware ornaments of endless variety, by tiles for pavements and wall decorations, and the like. English energy has stirred France and Germany, the United States, and even such ancient rivals as China and Japan, to compete with us in the new markets which we have chiefly made. Every day, however, it becomes a more pressing question whether we shall be able to maintain the supremacy in this trade which we have acquired, or whether, as in other branches of manufacturing industry, we must be content to share the honours as well as the profits with some or all of these rivals.

It is evident that pottery, unlike many others, is not a trade that can be to any great extent localised by natural causes. Unless very great hindrances are offered, machinery and tools of every kind will always be made most conveniently, and therefore most abundantly and most cheaply, within easy reach of coal and iron mines; and the attractions of iron and coal fields are so strong that, as events have proved, the raw materials for cotton, woollen, and even linen and silken fabrics will travel half round the world to be manufactured where the requisite machinery is most accessible. But the principal ingredient of pottery is to be found everywhere, and though good machinery and cheap fuel are becoming more and more essential to its economical production, it may easily happen that there will be more advantage in conveying them to the places where the best clay and, yet more, the best workmen are to be found than in conveying clay and workmen to the centres of machine making and fuel supply. Staffordshire, it is true, has held its ground as the chief pottery district in England, although most of the clay used in its finer work is now brought from Cornwall, Devon, and Dorset; but with this the wealth of Staffordshire in iron and coal has had much less to do than the fact that the people in Burslem and round about it were potters by inheritance, and that Wedgwood and so many other leading men in the revived trade belonged to the same district. In the new centres of the trade that are being established, as in America, we find that cheapness, efficient command of labour, and conveniences for disposing of the goods produced are the main conditions of success. These,

therefore, are the principal points to be borne in mind in estimating our chances of continued prosperity in earthenware and other branches of the ceramic art.

Statistics, it must be admitted, neither show nor threaten any deterioration of our trade in this respect. Our exports rose steadily in value during many years before 1866, when they amounted to £1,685,864. Since then they have advanced more slowly, except that there was a sudden and temporary excess in the unusually prosperous years of 1872 and 1873, and in 1877 they were stated at £1,766,690. Considering what great reductions in price have taken place in recent years, this slight increase in value indicates a large increase in quantity. Though our trade, both at home and for exportation, is undoubtedly growing, however, its growth does not keep pace with the increased demand of foreign countries and our own colonies for earthenware and kindred goods. Nearly every country is augmenting its home supply or buying more than formerly from markets which, in certain respects, suit it better than the English. This, of course, is partly due to the protective duties which so many of our rivals have adopted. France, for instance, which exports little besides small quantities of meretricious work, is gradually forcing its inhabitants to dispense with English manufactures. The same may be said of Germany, which distributes throughout Northern and Central Europe coarse, strong stoneware, adapted to the tastes and requirements of the people, in sufficient quantity to almost destroy the trade with those parts which was formerly possessed by England. But it would seem that the most dangerous competition with which we are threatened is offered by America. Up to a recent date, France, continuing the business that naturally devolved upon it when Canada was its colony, supplied the Canadians with most of the earthenware and porcelain which their own rude factories were not able to furnish, and its trade in these goods gradually came to be more extensive on the south than on the north side of the St. Lawrence. The greater energy of the English has driven France almost entirely out of the American markets, but England now finds itself face to face with the more formidable opposition offered by the people of its own race in the trans-Atlantic continent.

The history of American pottery is very instructive. From early times, of course, both Canada and what are now the United States made a good deal of the coarser and homely ware which it would be too expensive to bring across the sea. But more than a century ago we find Wedgwood expressing alarm as to the effect on English "trade and prosperity" of the skill and enterprise that were showing themselves in Philadelphia. During the American war with Great Britain in 1812, and afterwards, native industry was quickened, but when peace was restored it could not, for fine workmanship, rival the produce of Europe. "Until about the year 1830," says General Hector Tyndall, in an interesting memoir on the subject, "no effort was made to enlarge the number of potteries other than those for making such kinds as could not be imported profitably because of their cheapness and bulk. About the year named a porcelain manufactory was begun in Philadelphia, in which was practically shown the possibility of making in commercial quantities a hard porcelain of good and serviceable quality by using only the materials found abundantly in many parts of the United States. This serious attempt lasted for several years. The products were white and decorated table and tea services and ornamental pieces." Prosperous for a time, however, this undertaking failed after a few years, and other attempts to produce superior porcelain and earthenware were not more successful till 1866, when some prolonged endeavours at Trenton, in New Jersey, issued in the establishment of a factory which, applying itself especially to rival the "white granite" wares that were till then largely imported from England, proved that this could be done satisfactorily. The trade may be said to have been fairly entered upon in 1870, and while Trenton already abounds in factories and bids fair to be the Burslem of the United States, the business is extending to Liverpool in Ohio, Greenpoint in New York, and other places. The Americans are quite resolved, if they cannot replace all the pottery imported from Europe, which for some time past has averaged nearly £1,000,000 a year in value, chiefly from England, that they will at any rate divert a large share of it, and make further profit by sending abroad much of their produce in competition with that of the English makers. "The prices of their wares," said General Tyndall in 1874, "are low, in relation to the cost of labour in the United States. The processes employed are of the most improved kinds, and the potteries are well arranged, very orderly, and highly commendable. All the materials used are found in the United States, and generally within a short distance of the several works. There are now a large number of

these works, which, excluding terra-cotta and brick potteries, on a capital of about £2,000,000, employ about 12,000 to 15,000 persons, and give an annual production of about £1,600,000 to £2,000,000 worth of goods. Of these the white granite and cream-coloured wares have about 30 manufactories, with about 110 kilns, having a capital of £750,000, employing about 3,500 persons, paying about £250,000 yearly wages, using from about 50,000 to 75,000 tons of coal, and about the same quantity of other material annually, and producing about £600,000 worth of wares per annum." England is still, of course, immensely ahead of the United States, both in the extent of its earthenware trade and in the quality and variety of its produce, but the giant strides which the trade is now taking in America must not be thought lightly of, especially when we remember that nearly every kind of clay employed in pottery is to be found there in abundance, that fuel and machinery are plentiful, and that there is no lack of skilled labour at a lower rate than can be obtained in England. As regards labour, it is especially noteworthy that, though they do not seem yet to have been thus employed, the United States have at command an unlimited supply of Chinese workmen, among whom porcelain manufacture has been an inherited art for more than a hundred generations.

In China itself, and yet more in Japan, it must be remembered, the growing European taste for "china" of all sorts has given a great impetus to their ancient trades, which are not likely to flourish any the less because in them the deteriorating influence of the bad taste of many European customers is apparent. The splendid demonstrations of their skill made by the Japanese especially, at the International Exhibitions in Philadelphia in 1876, and in Paris in 1878, which astonished every visitor, gave evidence of the vigour with which they are prepared to contest the rivalry of England and other nations. There are at least thirty-five great centres of porcelain and earthenware manufacture in Japan, which between them produce almost every conceivable variety of workmanship, all remarkable for the inventive genius and artistic power displayed in their design and execution. Hitherto, the Japanese, like the Chinese, have sent into Western markets, or rather, have allowed "barbarians" to carry thither, specimens of their skill too quaint and rich for general use; but now that they are competing with English and other manufacturers, it is not easy to over-estimate the success with which their competition may be carried on.

In the foregoing remarks the term earthenware has been generally applied to all kinds of potter's work. It is hardly necessary to observe that porcelain, of which there are numberless varieties, is not technically classed with earthenware, and that there are many different manufactures of clay which cannot properly be ranked with pottery. Brick-making, the most extensive of these trades, is not one in which there can be much competition between different nations, as the article must almost necessarily be produced near to the spot in which it is to be used. There is room for considerable competition, however, in respect of some of the substitutes that are now offered for bricks in certain special purposes to which they are applied. Who can say how much profit is in store for the people who may bring into general use the floor and wall tiles and the terra-cotta architectural decorations which have been lately introduced? In both, England has thus far taken the lead. "The importance of terra-cotta for architectural purposes," says Mr. John Smith, the keeper of the National Art Library at South Kensington, "especially in a climate such as ours, renders it in the highest degree desirable that manufacturers should turn their attention still more to its production. It is also to be hoped that their efforts to promote its use may not be hampered by combinations of workmen prejudiced against its introduction. As a material for the surface and decoration of buildings in cities where the impure atmosphere injuriously affects many kinds of stone, terra-cotta is unequalled. In this country its introduction is at first encountered by apathy, by dislike of apparent novelty, and by difficulties created by combinations of workmen. These obstacles do not arise in America, and it is therefore more essential that the existing superiority of the material, as produced in England, should be fully maintained if English firms are to continue to supply their terra-cotta to American architects."

Though their methods of manufacture are so different, glass is sufficiently akin to pottery, especially in some of the ornamental uses to which it is put, for them to be included in the same category. Glass-making gave occupation, when the census of 1871 was taken, to more than 20,000 persons in Great Britain, and the number is now probably much greater. The prospects of the trade, as an important branch of English industry, however, are far from encouraging. In 1863 the glass of all sorts which we exported was valued at £759,333; in 1870 it had risen to £832,716; and

in 1877, after reaching a much greater height in 1872 and 1873, it was as high as £1,054,469, having thus increased nearly forty per cent. in fifteen years. The imports, however, which were stated at £434,417 in 1863, amounted to £931,467 in 1870, and to £1,908,167 in 1877, showing an increase of nearly 340 per cent. in the same period of fifteen years. Though we still send large quantities to the United States, Australia, and India, it is reckoned that at least a third of all the plate-glass, and at least three-fourths of all the sheet-glass, used in our country now come to us from Belgium and France, to neither of which countries do we send any of our own making.

For that unsatisfactory state of things our glass manufacturers blame the protective tariffs imposed by our neighbours. On the other hand, we may reasonably find fault with our forefathers for hindering England from becoming the chief glass-making nation in the world. Glass was not much used in our island before the middle of the sixteenth century; and even in 1673 it was a novelty for the second Duke of Buckingham to bring over Venetian artists to open at Lambeth an establishment for the manufacture of window-panes, mirrors, and other articles. The trade had been brought from Italy into France and Belgium somewhat earlier than that, and in England it was seriously crippled, to our neighbours' advantage, by the monstrous taxes levied upon it by the Legislature. In 1819 it was thought a great concession to reduce the duty to sixty shillings a hundredweight, but that was still high enough to keep the trade at a very low ebb. During some years before 1836 there were only two glass factories in England, and in that year they produced only about 7,000 square feet in a week. The number of establishments had increased to six in 1845, when the duty was removed by Sir Robert Peel. "If you have the manufacture altogether disburdened, as in France and Belgium," he said on that occasion, "then, with your peculiar advantages of material and your command of alkali and coal, my belief is you will supply almost the whole world." The change came too late for the prophecy to be fulfilled. It led to a wonderful development of the English trade, especially in crown and flint glass, for the latter of which Alum Bay, in the Isle of Wight, yields better sand than even Fontainebleau; but the French and Belgians, having been allowed for so long a time to take precedence of us, gained quite as much as we did by the removal of the tax. Before 1845 hardly any foreign glass was brought into England. In that year, the quantity imported from France and Belgium amounted to about 22,000 cwts. In 1877 it was as great as 612,593 cwts. The manufacture of sheet-glass, indeed, is still almost a foreign trade in England, as nearly all that is now made here is made by Belgian workmen brought over to exercise, for our and their own benefit, a craft in which long experience has given them greater skill than our own countrymen are possessed of. Plate-glass, however, for which we formerly depended chiefly on foreigners, is now naturalised among us. Our produce is valued at about £1,000,000 a year; and the quantity exported by us rose from 575,589 feet, worth £70,255, in 1863, to 1,157,063 feet, worth £128,663, in 1877. The different proportions between these figures, as regards quantities and values, illustrate the steady fall in prices which has resulted from the cheapening of materials and the improved methods of manufacture that have been adopted. In 1826 the coal consumed in making a square foot of glass was reckoned to cost in London more than 1s. 10d.; in 1875 it was only about 2d. During the same half-century, the price of sand, which constitutes about three-fifths of the ingredients of glass, sank from 18s. to 3s. 6d. a ton.

English manufacturers have some reason to complain of the injury done to them by the foreign tariffs, which almost shut them out from the continental markets, while enabling foreigners to undersell them at home. The Belgians, for instance, now supply us with a large quantity of inferior glass. In making, say, 15 cwts. of the best glass, they find it convenient or necessary to turn out about 85 cwts. of common glass. As English wares are kept away by protective duties, they are able to command, on the Continent, such a high price for their best glass that it pays them to dispose of the inferior sorts in England, or the English markets abroad, at prices with which English manufacturers cannot compete. It appears, however, that they are inclined to shelter themselves too much behind grievances like that, instead of considering how, by improved workmanship, they can push their trade. "Sufficient attention," says Professor F. S. Barff, "is not paid by English manufacturers to mixing their materials so as to form definite silicates, the result being that glass is produced with a striated effect. This is easy to be seen in the common kinds, as in bottle-glass; but owing to the more careful and prolonged fusion of the finer varieties, such as plate-glass, this defect is to a considerable extent remedied, though not altogether overcome. In the

French manufacture of plate-glass more attention has been paid to the chemical composition of the various silicates that enter into it." Some of the best glass in the world is now made in England; but if we are not to be worsted in the rivalry before us, no argument is required to enforce the warning that all our glass must be, of its kind, the best that can be made.

HEMP, FLAX, AND JUTE.—XXI.

DUNDEE AS A SEAT OF THE LINEN MANUFACTURE.

By David Bremner, Author of "The Industries of Scotland."

As the chief seat of the linen and jute trades in the kingdom, Dundee merits special notice. The commercial history of the town goes back to a remote time. When King David Bruce granted a charter to the town in 1358, it was described as a place "wherein there is great trade of merchandise, and whereunto there is made great resort and repair of people." Mention is frequently made at subsequent dates of its fleet of merchant vessels and their troubles in war times. The making of linen cloth was early begun by some of the inhabitants, but at first only for local requirements. In course of time the trade developed, until at the Union (1707) the annual make reached 1,500,000 yards. A geographical dictionary, published in 1759, says:—"Dundee is one of the best ports for trade in all Scotland, particularly for foreign, yet has it considerable inland business also, especially for corn and linen cloth, which makes the country round about rich and populous, being maintained by the great quantities of goods which the merchants of Dundee buy for exportation." In 1773 the quantity of linen stamped in Dundee was 4,488,460 yards.

From a "Statistical Account of Dundee," drawn up by the Rev. Dr. Robert Small in 1792, we extract the following passage bearing on the linen manufacture:—"The principal and staple manufacture of Dundee is the linen of various kinds: first, Osnaburgs and other similar coarse fabrics of different names for exportation, and which alone, till lately, were subjected to the national stamps. The quantity of those stamped between November, 1788, and 1789, amounted to 4,242,653 yards, valued at £108,782 14s. 2d., and subtracting from this a fourth part, supposed to be brought from six neighbouring parishes into Dundee stamp offices, there will remain for the quantity made in this parish 3,181,990 yards, in value £80,587 8s. Second, all the different sorts of canvas for shipping. This fabric is entirely confined to the town, and the quantity annually made may be rated at 704,000 yards, and valued at £32,000. The cloth of this kind made by some of the principal manufacturers is thought to be superior in quality to any other in Britain, and by a regulation now introduced—and for which we are chiefly indebted to Mr. Graham, of Fintry—of subjecting it to public stamp-masters will probably retain its character. A process is also known by which the buyer, at a small and distinct expense, may have it effectually secured from mildew. Third, sackcloth, principally for the consumption of the neighbouring country. The quantity annually made may amount to 16,000 yards, and may be valued at £800. Fourth, bagging for cotton-wool, in quantity 165,000 yards, and in value £5,500. Fifth, some diaper, by one company lately established. Sixth, the greater part of the linen necessary for household purposes, but the quantity and value of this I cannot pretend to give. . . . The manufacture of coloured thread has been established in Dundee for fifty or sixty years, and was for a considerable time peculiar to it. This business is in the hands of seven different companies or parties, who use sixty-six twisting mills, and employ about 1,340 spinners, and 320 servants to make the yarn into thread. The quantity annually made is computed at 269,568 lbs., valued at £33,696. The spinners live in different parts of Scotland, where labour is cheaper than in Dundee. . . . The particular cause of the increase and prosperity of Dundee is undoubtedly the bounty allowed by Parliament on linen manufactured for exportation. By this the industry of the inhabitants was first set in motion and encouraged."

Returns of the import and export trade of Dundee in the years 1745 and 1791 show that a great increase took place in that period. We subjoin a few items bearing on the subject in hand:—

Imports.

	1745.	1791.
Flax from Russia	none.	2,348 tons.
Do. from Holland . . .	74 tons.	72 ,,
Hemp.	none.	299 ,,
Tow or Cordilla	none.	24 ,,

Exports, coastwise.

	1745.	1791.
Linen, brown and white .	1,000,000 yds.	7,842,000 yds.
Thread, white and coloured	12,544 lbs.	130,952 lbs.
Sail-cloth	none.	280,000 yds.
Cotton bagging	none.	65,000 „

Though flax-spinning on Kendrew and Porthouse's machines had been begun at Bervie and one or two other places in Scotland as early as 1787, it was not till five or six years later that the machines were introduced into Dundee. The first flax-spinning mill was erected by Messrs. Fairweather and Marr in Chapelside, but it did not prove successful, nor did a similar establishment erected soon after by Mr. D. Birnie in Guthrie Street. In 1798 three mills on a more extensive scale were fitted with flax-spinning machines, and formed the nucleus of some of the great factories still in existence. In the year 1800 there were in the town five mills, with steam-engines of 60 horse-power in the aggregate, driving about 2,000 spindles, and producing 5,000 spindles of yarn per week. Seven years later there were only four mills running, with a slight increase of engine-power. This must not, however, be taken as an indication that the spinning trade had ceased to develop itself. A spinning machine of light construction had been devised, and found much favour for a time, and its presence probably had something to do with the check given to the introduction of steam machinery. The frames contained twenty or thirty spindles each, and were worked by manual labour by means of a crank and treadle. Horses were tried as a moving power, but they were more costly than the other method. The driving of the machines was severe and monotonous, and as horses were not found to be profitable accessories, small steam-engines were tried. These had their run of popularity, but not of prosperity. Meantime the proprietors of the larger mills were making progress, and in the course of a few years the smaller concerns were abandoned.

West Ward Mill, subsequently called and still known as the Bell Mill, was the largest of the earlier spinning concerns. It was built by Mr. James Brown in 1807, the plans and machinery being obtained from Leeds, which town had then become famous as a seat of the linen manufacture and machine trade. The building was ninety-seven feet long, forty feet wide, and four storeys and attic in height. It was furnished with forty spinning frames for flax and tow yarns, a number of twisting frames, together with the necessary preparing machinery. The motive agent was a steam-engine of twenty-five horse-power. The cost of the building was £7,000, and of the engine and machinery £10,000, so that for the time it was a very extensive concern, and no larger mill was built in the town for twenty years after it was started. The produce of the mill was 2,700 spindles of yarn per week, and the cost of spinning was 9½d. per spindle, divided thus: wages, 5d.; coal, 1½d.; oil, repairs, rent, and charges, 3d. By the year 1822 the number of flax-spinning mills in the town had increased to seventeen, which contained an aggregate of 7,944 spindles, driven by steam-engines of 178 horse-power, and gave employment to 2,101 workpeople. Ten years later the number of mills was forty, with engines of 683 horse-power, and a corresponding increase of machinery. By the end of 1835 the horse-power of the engines employed had increased to 1,299. The mills did not grow in number, but they were considerably extended. In 1851 the number of mills was still forty, but the engine force had increased to 1,830 horse-power. Several power-looms were introduced by manufacturers as early as the year 1821, but the experiments do not appear to have been successful, as in an account of the town written in 1833 it stated that "power-looms have not been employed here, or, at least, not to any advantage, and they are understood to be entirely laid aside." Messrs. Baxter built a power-loom factory in 1826, but having misgivings as to the utility of the machine, devoted the building to other purposes. In 1836, however, they built and equipped with power-looms another room, and thus became possessed of the first establishment of the kind in the town. Three other power-loom factories were erected about the same time, but a considerable interval elapsed before others were added.

Mr. Warden tells us that in the early days of mill-spinning it was with difficulty that a sufficient number of hands could be got for preparers, spinners, or reelers; and it was the practice in and around Dundee for the owners of mills or their managers to attend the neighbouring country fairs to engage hands; and sometimes open tent had to be kept all day as an inducement to the people to come to terms. Engagements were generally made for six or twelve months, and "arles" were given as earnest of the bargain. Work in the mills was new and little understood, and the prejudices against it and those who took employment in them were very strong. The hours of labour were long, ranging from fourteen to fifteen a day in towns, and in some cases they were even longer in country mills. The hours to be worked depended, in many cases, upon the caprice of the manager and the

cupidity of the mill-owner. Holidays were rare, and when they were granted it was on the understanding that the time would have to be made up by working extra hours. The Factory Acts altered all this, and conferred other valuable boons on the mill-workers, and under their influence the prejudice against this form of labour passed away.

Owing to the frequency with which out-door workers purloined the flax and yarn entrusted to them, stringent laws were passed for the repression of the practice. As samples of the operation of these laws, it may be mentioned that in November, 1804, a woman was brought before the Dundee justices charged with selling materials entrusted to her, and a man was charged with purchasing the same. The woman was, on conviction, sentenced to fourteen days' imprisonment and to be publicly whipped, while the man was fined £20, with the alternative, in case of non-payment, of a public flogging. In the following years six smugglers of hemp and flax were similarly punished.

During the successive periods of commercial depression that have been experienced during the present century, the staple business of Dundee has not escaped; and on one or two occasions the crisis was so sharp as to threaten the existence of the trade. Owing to various causes, the price of flax rose in 1809 to £150 per ton, and next year made a sudden descent to £80. The loss in stock, and the stagnation in trade which accompanied and partly produced the fall, ruined nearly all the merchants, manufacturers, and spinners, and for a time there were only two spinning mills at work in the town. During the next four years, fluctuations of prices nearly as violent took place, and intensified the mischief already done. Many bankruptcies occurred, and great suffering was entailed upon the working population. Things looked so bad that it seemed inevitable that the trade would have to be abandoned. Fortunately, a timely change for the better took place, and for six or seven years a run of remarkable prosperity was enjoyed. All went well until the autumn of 1825, when a commercial panic occurred in London, spread rapidly over the country, and on reaching Dundee dashed all the fine hopes that had been raised. Some of the leading manufacturers and merchants succumbed, and again great distress prevailed in the town. The stagnation of business became so serious that the Government were induced to render assistance to the merchants of the town, which they did by granting Exchequer bonds on deposits of goods. This relief enabled the traders to tide over the dark period. Early in 1827 a revival of the American trade took place, and once more the factories were put into full operation. Large quantities of cotton bagging were made for the United States, and as there was a large profit on that article, much benefit resulted to the town. The bounty on linen exported ceased with the year 1832, but during that year the Dundee manufacturers exerted themselves to earn as large a share of the bounty as possible. They succeeded in sending abroad linen to the value of £600,000, on which they received £46,854 bounty. Towards the close of 1835 a most disastrous fire occurred in New York, and among other commodities destroyed was a large quantity of cotton bagging. On learning what had occurred, the Dundee manufacturers addressed themselves most assiduously to the task of replenishing the stock of this article; but their eagerness to improve the occasion resulted in their overstocking the market to an enormous extent. Some of the goods sent out lay in store for years, and were ultimately sold at less than the cost of freight and charges. Again a number of the larger merchants and manufacturers were compelled to stop payment, and the usual results followed. The banks assisted to save the trade, as far as possible, by opening warehouses and giving advances on goods deposited. In course of time the trade rallied, and continued in a fairly prosperous condition till 1847, when the railway mania produced such baneful results. The manufacturers and merchants of Dundee, like their brethren in other quarters, joined in the speculations, and suffered in due course. When the Crimean war broke out, an extensive demand for coarse linen sprang up, and the manufactures of Dundee were largely consumed by both belligerents. Under the stimulus thus given new mills were erected and old ones extended, and the machinery was kept going at such a rate that in the course of a few months the markets were again overstocked. In 1857 came the great financial panic, in which two of the Scottish banks were compelled to close their doors. Dundee on that occasion suffered severely; the goods produced in its factories having fallen in value at least 50 per cent. The American war was the most fortunate event that ever occurred for the linen manufacturers of Dundee. Both armies became extensive purchasers, and for three years the factories were kept fully employed. Much wealth was realised, and many firms were able to accumulate sufficient capital to enable them to overcome any probable difficulty in the future. Since then there have been several fluctuations, and

during the last few years both the linen and jute industries of Dundee have been in a considerably depressed state. The rise and progress of the latter branch of business will be dealt with in another chapter.

In the year 1811 the quantity of flax imported into Scotland was about 6,000 tons, and of this quantity the spinning mills of Dundee took only 468 tons. The whole capital then invested in spinning machinery in the town did not exceed £22,000. In 1832 the mills in operation in Dundee and the immediate neighbourhood consumed 15,600 tons of flax, and produced 7,488,000 spindles of yarn. The sum then invested in machinery was estimated at £240,000. About 3,000 persons were employed in the mills. The return compiled by Mr. Warden in 1867 showed that there were in that year in Dundee 72 works devoted to the manufacture of flax, hemp, and jute. The nominal horse-power of the engines in these was 5,822; spindles, 202,466; power-looms, 7,992; persons employed 35,310.

DUNDEE.

The variety of fabrics made from hemp, flax, and jute in Dundee is remarkable, but it is not necessary to enumerate more than a few of the leading kinds: namely, sail-cloth, brown, boiled, and bleached; duck-sprigs, used as padding; sheeting, brown, creamed, checked, bleached, &c.; dowlas, diaper, and damask, Hessian shirting, sacking, hop-pocketing, bagging, tarpauling, hammocking, carpeting, hearth-rugs, wadding, &c. It only remains to say that all the yarns spun in the town are not woven there, but a large quantity is exported to various foreign countries, where its qualities are highly appreciated.

SHIP BUILDING.—XXII.

THE SURVEY AND CLASSIFICATION OF MERCHANT SHIPS.

MANY Acts of Parliament have been passed relating to British merchant shipping, but that of 1854 is the foundation of all the regulations at present in force, its most important extensions being contained in the Act of 1876. The Board of Trade is the department chiefly concerned in the preparation, as well as the administration, of these laws, and it has been endowed with large discretionary powers. But it still remains true —and we trust always will remain true—that Government inspection and survey have regard only to the *seaworthiness* of merchant ships, the ship-builder and ship-owner being left free in their work of designing and constructing ships. To this free action we owe those remarkable developments of the British mercantile marine that have been described in previous chapters; and it would be a misfortune if any extension of Governmental interference should fetter the daring and genius of our ship-builders and engineers. There have been many proposals for such interference on the ground that Government should secure proper precautions for the safety of life at sea. Strenuous objections have been raised to such proposals, both by ship-owners and by the officials of the Board of Trade. On the one side, the ship-owners protest against interference in matters relating to the design and construction of their vessels; on the other, the officials demur to the suggestion that they should assume weighty responsibilities properly belonging to the owners and builders. The weight of opinion is decidedly against an extension of Governmental inspection beyond the limits it now reaches, which limits have been fixed after the careful inquiries and exhaustive reports of the Royal Commission on Unseaworthy Ships—better known as the "Plimsoll Commission"—appointed in 1873. It is impossible to speak too highly of the labours of Mr. Plimsoll; and it is a matter for congratulation that his chief object was attained—viz., the practical extinction of that class of unseaworthy ships which were sent to sea by unscrupulous owners, insured far beyond their real value, so that their loss frequently resulted in a substantial monetary gain to the owners, although, unhappily, often accompanied by loss of life to the crews. The storm of indignation against such malpractices raised by the publication of Mr. Plimsoll's book resulted in some temporary injustice to the whole class of ship-owners. It must be recognised, however—and Mr. Plimsoll himself was careful to make the distinction—that the unscrupulous owners whom he attacked were the exceptions, by far the greater number of British ship-owners being honourable men, anxious to make their vessels safe, seaworthy, and efficient, without the constraint of legislative enactments or official survey. The Royal Commission, recognising this important distinction, were careful to indicate the dangers to our maritime supremacy which would arise were restrictions placed upon British ship-owners, engaged, as they are, in active competition with other energetic mercantile communities. Nor did the Commission fail to notice the important services rendered by the various voluntary organisations for the survey and classification of merchant ships, originated by the underwriters and societies which undertake the business of marine insurance. Individuals or companies insuring ships and cargoes have the strongest reasons for securing evidence of the seaworthiness of the ships insured, quite apart from action taken by officers of the Board of Trade. Hereafter we shall give an account of the working of these "Registration Societies" and "Salvage Associations," but in passing we cannot forbear from remarking that these organisations furnish evidence of the power of self-government which has done so much to aid our commercial progress. Exception may be taken to some of the results of the working of these societies, but on the whole they have been decidedly beneficial to the mercantile marine, and they have been imitated abroad. Their success is the more remarkable when contrasted with the "remedial legislation" of the last thirty or forty years. The Royal Commission of 1873 reported as follows:—"Parliament has during many years been engaged in attempting to regulate minute details connected with shipping. Ship-owners reasonably complain that they have been harassed in their business by well-intended but ill-contrived legislation, and that this legislation is enforced by a department imperfectly acquainted with the science of ship-building and with the interests of our commercial marine. The officers of the Board of Trade admit that many enactments designed to secure safety of life at sea have been mischievous, and should be modified or repealed. The amount of

legislation and the multiplicity of details connected with shipping which are now regulated by law have not been altogether successful, and it seems that the results aimed at are hardly attainable by Acts of Parliament." It would be an unprofitable task to describe in detail the legislation thus condemned, even if space permitted. We propose, therefore, to confine attention to the present practice of the Board of Trade in making surveys of merchant ships before passing to a description of the voluntary organisations for registering and classifying those vessels.

By the Merchant Shipping Act of 1876 it is declared that "every person who sends or attempts to send, or is a party to sending or attempting to send, a British ship to sea in such unseaworthy state that the life of any person is likely to be thereby endangered shall be guilty of a misdemeanour, unless he proves that he used all reasonable means to ensure her being sent to sea in a seaworthy state, or that her going to sea in such unseaworthy state was, under the circumstances, reasonable and justifiable." Under this Act the Board of Trade must at least consent to a prosecution before it can be instituted; and, by its officials in the various ports, it keeps watch to prevent the departure of unseaworthy ships. These surveyors do not undertake an inspection of merchant ships while building, nor need they interfere with the stowage or most parts of the equipment; but as representatives of the Board of Trade they have powers to detain any ship which "is, by reason of the defective condition of her hull, equipments, or machinery, or by reason of overloading or improper loading, unfit to proceed to sea without serious danger to human life." This power of detention was first granted in 1873, and in many of the earliest instances its exercise was due to the energetic action of Mr. Plimsoll. It can easily be understood that such discretionary powers require to be used cautiously and wisely by competent and experienced officers. Detention means for the ship-owner serious inconvenience, and possibly great loss; consequently, grave objections were raised to the assumption of such powers by the Board of Trade, but these objections have been over-ruled. After several years' experience it is generally admitted, we believe, that, on the whole, the new Act has worked well. There have been cases where ships have been detained on insufficient grounds, the owners ultimately obtaining substantial damages from the Board of Trade; for the Act was framed in a fair and equitable spirit, and gave to the ship-owner the right of appeal to competent tribunals. Speaking broadly, it may be said that at the present time the great majority of British merchant ships go and come without interference on the part of the Board of Trade surveyors; that in certain cases, which are comparatively few in number, ships are provisionally detained until, in lading, outfit, or some other particulars, they are made seaworthy; and that in still fewer cases, after ships have been provisionally detained, the machinery provided by the Act is set in motion to test the justice or otherwise of the verdict of the Board of Trade officials. When a ship has been provisionally detained the fact is reported to the Board of Trade, and the master of the vessel is informed of the reasons for detention. The Board of Trade, on receipt of the report, either confirms or rescinds the order given by the surveyor. Supposing it to be confirmed, then the owner or master of the ship may appeal to the "Court of Survey," or in cases of doubt the Board of Trade may refer them to that court. Each port or district may have such a court according to the Act, and the judge is to be assisted by two assessors—"persons of nautical engineering, or other special skill and experience." Furthermore, in cases of special difficulty the Board has the power to call in the assistance of "scientific referees," who would have the same powers as a judge of a Court of Survey. The purpose of all these arrangements is clearly to enable cases which arise to be dealt with quickly and fairly on the spot, and this purpose must commend itself to the approval of every one. But the success of the whole scheme depends primarily upon the character and competence of the surveying officers appointed by the Board of Trade. Since the new regulations have been made the staff of surveyors has been considerably increased; and, as might have been expected, where the expansion was so sudden, this staff includes surveyors of very various degrees of efficiency. Amongst persons acquainted with the facts there is a feeling that, while the out-door inspection has been well-cared for, the central or consultative office has not been sufficiently strengthened by the appointment of highly-trained naval architects and marine engineers. Having assumed the responsibility of judging whether or not ships are seaworthy, the Board of Trade ought to have amongst its officers men capable of grappling with the many abstruse problems relating to the lading, the stability, and structural strength of ships, as well as officers of great practical experience as shipwrights, engineers, and seamen. We see no reason why, from the beginnings already

made, the professional staff of the Marine Department of the Board of Trade might not be developed in such a manner as to command the confidence of ship-owners and ship-builders generally. Active interference on their part with details of design is to be deprecated; but their examination of new projects, when voluntarily submitted by the promoters, might prove of great assistance, and avoid the possibility of litigation or disputes at a later stage. At present, as regards merchant ships, other than passenger steamers and emigrant vessels, the Board of Trade does not interfere until the time when the ships are about to go to sea. It can be readily imagined, therefore, that in any case of the introduction of novel types of ships or engines, after the work had been done at considerable cost, the surveyors might interpose with objections and suggestions that would be far more appropriate while the scheme was still only on paper.

These remarks are made in no unfriendly spirit, but rather with the hope that they may further the objects aimed at in the introduction of the new system.

There can be no question that the fear of detection and its consequences have had a very wholesome influence already upon the owners of unseaworthy ships, and that the sailor has benefited from the action of the new law. But it would be a great misfortune if, in the future, the action of the Board of Trade and its surveyors should tend to discourage private enterprise or attempts at improvements. The utmost freedom should be continued to British ship-builders and marine engineers; unless it can be shown that any new arrangements are dangerous to life and property, these novelties should be applied and practically tested; and if there is a necessity for inquiry into some doubtful, though promising, proposal, the inquiry should be conducted by a committee consisting not merely of officers of the Board of Trade, but including representatives of our great private firms and the "scientific referees" named in the Act. These are the conclusions to which one is conducted on an impartial review of the whole subject of Governmental inspection of the mercantile marine.

It should be explained that in the foregoing remarks attention has been directed to the common case, and that there are two classes of ships which receive special attention from the officers of the Board of Trade: passenger steamers and emigrant ships have for many years past been subjected to special surveys, and are granted special certificates by the Board of Trade. These surveys include the hull of the ship, her machinery, the boats, lights, life-buoys, signals, &c.; the inspection of crew spaces, and the inspection of provisions, medicines, medical stores, ventilation, &c. It was held that these surveys by Government officials were justified by the fact that "the passengers usually carried in these ships are totally ignorant of seagoing vessels, and therefore require the protection of the Government." Ordinary merchantmen, not carrying passengers, did not come under survey until 1873, the assumption being that their crews were better informed and capable of self-protection. Under existing regulations the lives of sailors as well as those of passengers and emigrants are, to some extent, cared for by servants of the State.

Turning from the Board of Trade surveys to those made by officers of the private registration societies, we enter upon clearer ground. Every one admits that these societies have tended to improve the character of British merchant ships, although they are not free from objections. The oldest register is that so well known as "Lloyd's;" it is said to date from about the middle of the last century, and was originally established by the underwriters for their own information in effecting insurances upon ships and cargoes. Lloyd's Register must not be confounded with the powerful association of underwriters known as Lloyd's, which takes its name from the coffee-house where a club originally met to transact business connected with marine insurance. The Register, it is true, exists primarily for the use of persons interested in marine insurance, but it is now managed, and has been managed for nearly half a century, by a committee consisting of merchants, ship-owners, and underwriters. The business of the Register is to survey and classify merchant ships. There is a very numerous and capable staff of surveyors stationed at all the principal ports of the United Kingdom and in various foreign ports. Ships are "classed according to their construction and quality, the materials employed, and the mode of building. The classification is entirely voluntary. There is, however, a strong inducement for a ship-owner to have his vessels classed, inasmuch as a classed vessel can be insured on better terms, and is also preferred for the conveyance of cargo." The committee issue detailed rules for the construction of wood, iron, steel, and composite ships; they undertake the survey of ships while building, and during the whole time of service of a classed ship their surveyors are supposed to be acquainted with her

condition, the owner being bound to submit her to inspection after certain definite periods have

PORTRAIT AND AUTOGRAPH OF SAMUEL PLIMSOLL, M.P.

elapsed, and to perform such repairs as may be necessary to the satisfaction of the surveyors. If the owner finally decides to dispense with the classification, on the ground that the expense of the repairs is too great, he is at liberty to do so. Lloyd's Register Book consequently presents three descriptions of vessels: those *classed* in the different grades, those which have been *dis-classed*, and those which have never been classed in the Register. In the last-named category are included

many of the largest and finest ocean steamers; the companies which own them not caring for the classification, and in many cases effecting their own insurances. From a statistical return, published in 1874, it appears that there were then afloat about 11,500 British ships, having a tonnage of 100 tons and upwards. Of these, over 6,100 ships were classed at Lloyd's, and about 5,000 ships were unclassed. About 500 of the unclassed ships belonged to the great steamship companies, and no less than 2,600 out of the remaining 4,500 ships are said to have been "dis-classed." It was amongst these dis-classed ships that by far the greater number of the casualties occurred, which led to the appointment of a Royal Commission and the passing of the new Merchant Shipping Acts. A writer on "Shipping Legislation" having analysed the returns of losses of British ships of 100 tons and upwards in eighteen months of 1874-5, states that, excluding cases of stranding, collision, &c., the percentage of unclassed ships which were lost was nearly double that percentage for classed ships. And out of 418 ships stopped by surveyors of the Board of Trade, about the same time, no less than 406 ships were declared unseaworthy, all of which were unclassed. These figures justify the high estimate which underwriters attach to classification when insuring ships, as well as the desire of merchants to embark their goods in vessels having a high class.

Besides Lloyd's Register, there is the Liverpool Underwriters' Registry, which began work in 1862, and is limited to iron vessels. Its operations do not compare in magnitude with those of Lloyd's Register; and it has been alleged that in the competition between the two societies to secure the larger share of classification business in new iron ships, some unwise reductions have been made in scantlings and structural strength. With these matters we are not concerned; but it may be well to state that since 1875 these objections have become less forcible, and both societies have aimed at securing ample strength in the ships classed, and ensuring that they are kept in good repair.

There is a third registration society, in which a considerable number of British merchant ships are classed as well as foreign vessels. The *Bureau Veritas* was established at Antwerp in 1828, and has since been widely extended in its operations. It differs from Lloyd's and the Liverpool Registries in this important feature, that it is a private company, not under the management of underwriters, merchants, and shipowners, but conducted on commercial principles, and with a view to profit. Neither Lloyd's nor the Liverpool Registry aim at doing more than meet their average working expenses, and, having a surplus, or reserve fund, it happens in some years that their receipts from fees for surveys and other sources do not meet the expenditure.

Having regard to the good work done by the two English registration societies in the survey and classification of ships, it is natural that many persons should advocate an extension of the system, and the substitution of compulsory survey for voluntary registration. The Royal Commission carefully considered this suggestion, and rejected it on what must be admitted to be good grounds. They reported as follows:—"The Government is not concerned, as the registries are, to ascertain whether a ship is fit for the conveyance of dry and perishable goods, but merely whether the ship is seaworthy. A Government certificate would therefore include a lower grade of ship than would be admitted at least in the higher classes of these registries. Such a system, including under one certificate the inferior as well as the best vessels, would discourage improvements in ship-building. . . . Voluntary associations may modify their rules as experience may guide them, and shipowners can withdraw their ships from the register or adopt the new requirements. If, however, a public department, having imposed compulsory rules, were suddenly to change them, great inconvenience would ensue to the whole mercantile community. On the other hand, if the Government or any authorised body could say this or that mode of construction is legally sufficient, and shall receive our certificate, the ship-owner, on compliance with the law, would be relieved from all further care in this respect, and would seek nothing beyond its requirements."

Even as matters now stand, the good which the registration societies do is not unmixed with evil, owing to the tendency to stereotype methods of construction which are embodied in the rules issued by the societies. A ship-owner now desires his ship to be classed; the builder knows that if he strictly conforms to the rules he can ensure the classification, and in this fact lies a discouragement of efforts at improvement. It is true that the rules themselves are gradually amended and improved; but the enterprise of the individual shipbuilder is cramped by the knowledge that if he ventures into new paths he may fail to obtain a class, whereas, if he avoids novelty he is safe. We

are here recording the opinion of many eminent private ship-builders, but in doing so it is a pleasure to be able to add our personal testimony to the fact that a wiser and more generous policy has been pursued of late years in admitting to the highest classes vessels built on systems of construction widely diverging from the rules. Elasticity and comprehensiveness are qualities that should always be maintained in the management of the registration societies if they are to be most useful and efficient. The committee of Lloyd's have further evinced a wise discretion by adding, during the last seven or eight years, a number of highly-trained naval architects to their surveying staff, and the beneficial results have appeared in valuable investigations of the strength and safety of merchant ships.

It must be remembered that, while the registration societies carefully examine into the efficiency of the ships, their machinery, and their outfit, they take no cognisance of their lading, manning, or management, all of which affect the question of their seaworthiness. There are, however, so-called "Salvage Associations," which keep a watchful eye upon the lading and other matters not touched by the registration societies. The salvage and management of wrecked property constitute the larger portion of the work of these associations; but their influence in other respects is good, and must greatly assist the action of the Board of Trade surveyors.

In conclusion, it may be remarked that casualties and loss of life at sea must not be attributed wholly, or even chiefly, to defects in the ships or their machinery. For instance, in the period 1856-72 it is estimated that 711 ships were lost by neglect or bad navigation, whereas only 60 ships are known to have been lost from defects in the ships or the stowage. Absolute safety at sea is, of course, unattainable; disasters sometimes happen even to the best-designed and most carefully-equipped ships. But, although many mistakes may have been made in the agitation which led to recent legislation, it will be clear that good has resulted therefrom. The British seaman is now less liable to be made the victim of unscrupulous owners, who formerly kept ships running years after they should have gone to the breaking-up yard. Under the present *régime*, if wisely conducted, still further improvements may be hoped for, and the number of ships detained or declared unseaworthy ought to grow less and less.

WOOL AND WORSTED.—XX.

THE FINISHING PROCESSES—FRIEZING, PRESSING, LUSTERING, MEASURING, AND PACKING.

BY WILLIAM GIBSON.

FRIEZES of all kinds are less popular than they were in this country some years ago. Originally introduced by French manufacturers, they attracted considerable attention for a time, and were universally worn; but since tweeds, meltons, diagonals, and fancy goods generally, have been brought to their present pitch of perfection, they gradually ceased to be inquired for. We still continue to make them, however, though chiefly in rough, heavy materials for capes and overcoats, and to be shipped for the colonies and other countries where our manufactures come into competition with those of France. A few words will enable us to explain how the small, button-like tufts on the surface of the cloth are obtained. Generally, the dressing is not so close as for ordinary West of England and similar cloths, in order that the tufts, or duvets, may the more easily be formed. The cloth was drawn across a narrow table or frame by means of rollers so as to give it a very slow progressive motion. The workman used a tool the underside of which was covered with a stone-like compound of a resinous putty, into which was rubbed hard, coarse sand and iron filings that had been passed through a fine sieve. This, when dry, became very hard and rough-gritted, forming a surface which, when applied to the pile with a certain pressure, and with a circular motion, caused the adjacent fibres in the pile to become knotted, and the surface assumed a friezed appearance. As the material gained in public estimation it became needful to accomplish by machinery what was a somewhat tedious operation when done by hand. A rather ingenious machine was the result of the engineering skill of those who turned their attention to this class of manufacture. The piece was made to pass over a table as before, but the table-top had an eccentric oscillating motion which was communicated by a

pivot curved vertically, placed in a notch large enough to give the requisite swing, and forming the top part of a vertical shaft. A round, flat, wooden tool, whose diameter agreed with that of the width of the table, was fixed in gearing and made to revolve very rapidly on the surface of the cloth. The latest form of the friezing machine, while retaining the fundamental characteristics of that just described, varies considerably in detail, but practically it has remained unaltered since the beginning of the century. Originally, we believe, the invention is due to a Dutch manufacturer, and at one time it was very generally in use in England and France.

Pressing has for its main object to render brilliant, and of the same tint, all the fibres in the duvet, or pile, by squeezing it between hot plates. For this purpose the piece of cloth is brought to the hydraulic press folded into a pack in lengths of about a yard. Between each of the folds is laid first a sheet of glazed paper or thin cardboard so that the surface of one length cannot come in contact with that laid above it. At every fifteen or twenty folds a thin iron plate is placed upon the cloth, and over this three iron plates heated in a furnace, a second thin cold plate being put upon the top, another length of fifteen or twenty yards is superimposed, each fold being treated in the same way. When the press is full, the hydraulic power is allowed to have play and the folds of cloth are squeezed together as tightly as possible. The heat from the hot plates penetrates the folds above and below, and the whole surface of the piece is brought under the influence of the warmth. The result is that the pile is softened by the heat, smoothed into a flat shining surface by the pressure, and made to assume the appearance of finished broadcloth. In former times, when the hot plates were quite cold, they and the glazed paper were removed and the cloth re-folded so as to bring the creases of the first folds into the centre of the press; but now, instead of their being large enough to cover the whole space, they are of such a size as to leave a loose space at each end of the fold. The movable portion of the press was the same size as the fresh plates, so that when the cloth was removed, after undergoing this second pressure, no wrinkles or creases were visible except in the case of broadcloth, which was folded in two across the width, and a crease ran down the entire length of the piece.

More recently, instead of solid plates, which had to be heated in the fire, hollow plates have been brought into use. These are so constructed as to allow of a stream of hot air or steam being passed through them, and thus keeping them at a uniform temperature till sufficient gloss is obtained. Another benefit in these hollow plates is that the pressing of any number of pieces is considerably accelerated.

So long as this hot pressing was alone applied to a piece of cloth there was no means of making its brilliant surface permanent, for the simple reason that a slight shower of rain would cause it to appear spotted, or careless brushing would unnecessarily disturb the uniformity of the pile. The result was that as soon as a dress-coat had been worn in a shower it had to be sent to the tailor to be pressed anew. As this was done piecemeal by a hot iron and a damp piece of cotton, the result was not always satisfactory, and the garment looked dull and shabby before it was on the wearer's back perhaps above twice or thrice. Consequently, the finest kinds of broadcloth had only a very moderate gloss put upon them, and people were careful to keep them out of the rain. To obviate this too rapid disappearance of the glazed surface a process of decatting was suggested. The earliest mode of lustering, or decatting, was to roll the cloth round an iron cylinder very carefully so as to obviate all creasing or wrinkling. Roller and cloth were then immersed in water kept at an even temperature of from 160° to 180° Fahr., according to the season of the year. Having, so to speak, been boiled in this way for six or eight hours, the cloth was taken out, unrolled and dried either in the open air, in hot-air chambers, or upon hollow cylinders charged with steam. The operation was repeated from eight to a dozen times, according to the quality of the cloth; the various boilings and dryings occupying ten days or a fortnight. No doubt the lustre given in the hot-press was thus permanently fixed on the surface of the cloth, but perfect lustering was a costly process. In consequence of the length of time absorbed in this operation means were sought to do the work equally well and with greater rapidity. A much better process was the steam-press, no doubt suggested by the pressing-machine. The table of the steam-press was hollow, and perforated on the surface, a feed-pipe to admit the steam and a waste-pipe to receive the condensed vapour being supplied. No paper was now required to be placed between the folds, the first object being to allow the steam free access to the cloth. But in order to prevent too rapid evaporation the pile of cloth put into the press was enveloped in glazed or oiled cloth so as not to interfere with the application of the necessary pressure to the pile. The steam, having been turned on, began, in course of time, to condense into water,

and then a very gentle pressure was applied at first. A second, a third, and a fourth steaming followed, the force of steam being increased at each application as well as the pressure applied to the cloth. By this means lustering was more rapid and the cost considerably lessened. The steam press had its advantages. For example, it was found that the vapour removed more readily than water any soap or grease that might have been left in the piece in the processes of fulling or scouring, and that the surface of the cloth more readily took a lustrous appearance. But it had also its disadvantages, not the least of these being the injury done to the health of the workman who was thus obliged to live for the greater portion of the day in a cloud; and, of course, notwithstanding every precaution taken to prevent it, condensation went on more quickly than was convenient.

M. Mouchard, of the famous factory of Elbœuf, devised an apparatus which he thought overcame the disadvantages of the steam-press. The principal organ in this machine is a crescent-shaped trough, the horns of which are rounded so that no injury may be done by the piece travelling over them. In the hollow of this crescent a hot cylinder revolves, and behind the cylinder and crescent there is a drying roller. The vapour is applied to all these parts by steam pipes, and is allowed to escape from the hollow of the crescent so as to come in contact with the cloth by a number of very minute perforations. One end of the piece having been passed by a pair of feed-rollers over one horn of the crescent, and over and under a series of four other rollers conveniently placed between it and the drying roller—so that a uniform tension is maintained throughout—is sewn into an endless band, while the steam is allowed to pass into the crescent and the cylinder working in it. Practically, it is found that the steam which meets the cloth in its passage round the hollow of the crescent does not waste, because the quantity escaping by the perforations is so little that it is absorbed by the hollow cylinder, and what little moisture remains in the cloth is dried by the drying roller round which it subsequently passes. As the piece can be made to travel continuously in the machine at a very rapid rate till the process of lustering is complete, there is a great saving of time. Since the construction of the first of these lustering machines, other agents have been added to assist the drying of the material, and the cylinder working in the crescent has been mounted so that the distance between it and the trough in which it revolves can be increased or lessened so as to suit all thicknesses of material, but it is found to operate best upon the lighter and finer fabrics. One other machine of this class may be mentioned, which retains the main features of the Mouchard with variety in the details. Here the crescent is replaced by a hollow trough, the tension of the piece is maintained uniform from beginning to end of the operation by a lever and weight pressing a semi-circle of iron upon the feed-roller, and the pile is brushed in a sense opposed to the march of the cloth by a series of cards over which it is made to pass on its way to the steam-trough. The pressure upon the cloth as it passes through the chief organ of the machine is regulated by a fly wheel which is mounted on a light pair of springs.

Measuring and folding, or rolling, were formerly the work of two distinct machines, but of late years they have been combined. In all other textile manufactures the piece once woven varies but slightly during subsequent operations, and then in a well defined ratio. With cloth this is not the case. We have already explained how the fulling, milling, and other operations entail a very considerable shrinkage, but unfortunately this is variable in different fabrics, and different kinds of wool. In order that the manufacturer may know the exact length of each piece that leaves his works it is almost essential that he should have a measuring machine, and as the appearance of the cloth is considerably affected by the manner in which it is rolled and packed, it is of some consequence that this should be done with the utmost regularity possible. The measuring machines in existence are very numerous in their varieties, and there is an almost endless series of apparatus for rolling or packing. It will be enough for us to indicate in this place the main features of those which are most generally in use, and which do their work with celerity and effectiveness. In the best machines the cloth passes over cylinders exactly a yard in circumference, and as the motion of the cloth sets this cylinder in motion, each revolution is invariably registered upon the measuring dial, down to the smallest fraction of a yard, and by connecting this with a rolling apparatus moving at the same ratio, the cloth is packed without wrinkle or crease on the wooden roller on which it reaches the merchant, or in folds a yard in length exactly, as may be the custom of the manufacturer.

We have now gone over in detail the whole of the processes necessary in the manufacture of wool, from its crude state into a piece of broadcloth or

doeskin, and it only remains for us, under this section of the inquiry, to add a few general observations upon one or two specialties in the manufacture introduced within recent years. Among these must be mentioned the endeavours that have been made to render cloth waterproof without adding to it any kind of substance that would interfere with the comfort of the wearer, or, in other words, to constitute it impervious to water while retaining its power of being penetrated by air. With all the heavier sorts of cloth there is a natural inclination in the raw material to absorb considerable quantities of water, and this is improved by fulling, pressing, and the other processes applicable to the article in course of manufacture. But with lighter materials, such as those used for summer overcoats and dust coats, it was needful to add some element to them that would help them to resist a shower. Waterproof cloth is almost exclusively an English trade, continental manufacturers being required rather to produce light materials that will resist the sun's rays than those which may be found useful in a humid climate like our own. It is not entirely a thing of the present to render cloth impervious to water, for long enough ago it was known that there were solutions of solids, which when applied to a texture would improve its power of resisting water. For instance, a solution of sulphate of alum and potash combined had the effect required; but what was not known was the proper proportions of the ingredients to be used, and some third substance which would cause it to amalgamate ultimately with the fibres of wool. These things are no longer a secret. Gum, or some gelatinous substance, was found to act most uniformly. The common practice, then, is to make a solution in which to every 1,000 gallons of water about 56 pounds of sulphate of alum, and the same quantity of acetate of lead are dissolved. To this are added about 400 gallons of Flanders glue, melted by ebullition, while both are hot. The mixture is then thoroughly incorporated by a mechanical appliance—such as that made for amalgamating any two substances that have no great affinity for each other—and allowed to cool. When cold the mixture is allowed to run off into a vat, and the cloth to be rendered waterproof, being perfectly dry, is plunged into it till it has absorbed as much as possible of the compound. It is then taken out and dried, either in the air or by some artificial means, and then, however light the texture, it is found to be almost impervious to water, even after being submitted to its action for a long time. As the cloth to be treated increases in weight, the proportions of the component parts must be increased. A new agent has been introduced by Messrs. Barnwell and Rollason. This is collodion and castor oil, but other oils, such as olive or colza, are equally efficacious. The material—for this mixture is used for silk and cotton as well as wool—having been made to absorb as much as possible, is placed in an atmosphere rising from 100° Fahr. to 300°.

Another novelty of modern times is the artificial production of a lustrous surface, the invention of M. Crace-Calvert. The glittering appearance is obtained by passing the cloth into a solution of some metallic salt, such as lead, copper, silver, or bismuth, and afterwards thoroughly drying it. Although this saves all the trouble of lustering, it injures the material more or less, and is apt to discolour under atmospheric influences. After being impregnated with the salt the cloth undergoes various other operations, all having the end in view of rendering the chemical lustering as durable as possible.

To explain the proportion of cost in manufacturing, M. Alcan has shown that whereas a century ago it would have needed 10,016 men to have produced a ton of cloth from a ton of wool in one day, the same thing could now be done by 1,897; a saving of nearly nine-tenths of labour!

It may be convenient at this stage of our inquiry to compare the quantities of cloth exported—for, unfortunately, we have no means of getting at the whole amount manufactured—and the prices of the wool a century ago as compared with to-day. The only mention of cloth manufactured is a return of cloth milled in the West Riding of Yorkshire. In 1727 there were milled 28,990 pieces, of probably thirty yards each; in 1777, half a century afterwards, we have a return of both broad and narrow cloths milled, and in that year, 203,536 pieces, containing 5,755,474 yards of cloth, were milled in this district alone. But this, at the most moderate computation, could not have been more than one-third of the entire manufacture of England, so that in round numbers, a century ago, we may safely conclude that 20,000,000 yards of woollen cloth were yearly produced. In 1717 the price of wool per tod was 19s., and in 1777, 21s.; a tod consisting of twenty-eight pounds. Now, a tod would be worth from £2 10s., to £3 10s. In 1827 the best computations show that the home yield of wool was nearly 109,000,000 lbs., and if we take the import to have been one-fourth, or say 27,000,000 lbs., we have a grand total for home consumption and

export of 136,000,000 lbs. of wool. Coming down half a century later, viz., 1877, we find that the total imports of raw wool for the first eight months of the year were 341,695,440 lbs., valued at £20,583,619. In that same year there were exported 29,007,400 lbs., valued at £4,527,160. The value of the foreign wool imported was on the average, 1s. 6d. a pound, or £2 2s. per tod. But the home production must be taken at least at five times the amount of the imports, and by adding one-third to the imports to account for the last quarter, the total imported is brought up to 512,543,160 lbs. for the year, which at an average of 1s. 6d per lb., raises the total value to £38,440,737. Then on the assumption that the home produce was five times that of the importation, we have the enormous quantity of 2,562,715,800 lbs. of wool grown in these kingdoms, which, added to the imports, brings the grand total of wool manufactured in this country to 3,075,258,960 lbs. used for various kinds of cloth. And, taking the average value at 2s. 3d. per lb., the total value of the wool amounts to about £345,966,633. Add to this the value of the wool imported, the grand total of the value of raw material manufactured into woollen cloth would be £384,407,370. These figures will give the reader some faint idea of the extent of the cloth trade, for we need scarcely say that in this computation we have excluded the long wools used in the worsted manufactures.

HEALTH AND DISEASE IN INDUSTRIAL OCCUPATIONS.—VIII.

MINERS AND THEIR DISEASES.

By Andrea Rabagliati, M.A., M.D., Hon. Surgeon to the Bradford Infirmary.

THE impartial inquirer into the varying merits of different occupations would, it appears to me, have some difficulty in finding any advantages accruing to the operative in coal mining, or indeed in mining in any form. To be obliged to leave the light and the fresh open air, and descend into comparative and sometimes into absolute darkness in the bowels of the earth, where the best efforts fail to induce fresh air to enter sufficiently; to lie on his side or back on damp or wet ground and drive his pick against the coal bank either horizontally or from below upwards, the nearest approach he can attain to the upright posture being sitting or stooping; to breathe continually during working hours a close and gas-charged atmosphere; to begin life by crawling on hands and knees while pushing with his head "corves" laden with coal, and to end it prematurely old, shaken with cough and exhausted by expectoration—if indeed some explosion of fire-damp has not sooner ended suddenly an existence doomed at best to painful termination—these are plain every-day incidents in the life of miners, and one may well ask what compensations, supposing there are any, in wages or anything else can be set against hardships so great and numerous. It is astonishing, however, to what circumstances the human frame can become accustomed, and it is a fact that some men pass a fairly long life even at such an occupation as coal mining, suffering much less in the course of it than we should be predisposed to believe. Coal mining is not exactly a healthy occupation, but still it is not so unhealthy as a survey of the conditions might lead us to expect. To show this let me quote the following facts furnished me by Dr. Drew of Chapeltown, a mining district near Sheffield. In a population, two-thirds of whom are coal miners and ironstone miners, the remaining one-third being farm labourers, shopkeepers, &c., the death rate for 1878 was at the rate of only 18·33 per 1,000. I do not quote this low death rate as representative of the general rate of mortality in this class of the population; but it shows what is generally admitted, that coal mining is not necessarily a particularly unhealthy or particularly dangerous occupation.

Besides accidents, which are out of the scope of this paper, the special affections of miners to which I wish to draw attention are chiefly three. Firstly, they are subject to diseases of the lungs; secondly, to diseases affecting the movements of the eyes; and thirdly, to a general interference with nutrition caused by the cramped position in which they are compelled to pursue their avocations.

It will not be necessary to dwell at great length on the lung diseases to which miners are liable, after the remarks which were made about the chest affections of wool-sorters. Miners suffer a good deal from bronchitis, and from consumption under a form known by the name of "miner's lung." These affections are due to two causes, dust and damp. The

dust is finely-broken coal-dust, and soot from the lamps used in lighting the workings. These are breathed in by the miners and act entirely as mechanical irritants in the manner described when treating of similar affections among wool-sorters. The penetrating power of this dust is very great. Thus it is found in the large and small air tubes (bronchi and bronchia), and in the form of a deposit under the lining membrane of the lungs (pleura), in the lung substance, and even in the air-cells. When the coal miner suffers from an attack of bronchitis, he very often gets rid of a black expectoration, which is found to contain particles of soot and finely-broken pieces of coal-dust. As the attack passes off, for there are generally repeated attacks of the disease, the expectoration becomes lighter in colour, and by-and-by quite clear. The irritant, or so much of it as was lodging in the bronchial tubes, has been got rid of for the time being. There is a physiological point of some importance to be noted here, namely, that the lining membrane of the air tubes is furnished with moving hairs called *cilia*. These cilia are like those to be seen in most persons just within the nostrils; only they are finer, and as a rule they move only in one direction, from within outwards, and their action is therefore to gently urge outwards any dust which may find its way from the outer air into the breathing organs. In the ordinary course of things, this action is sufficient to prevent any foreign bodies from gaining access to the lungs from the outer air, and, acting on their knowledge of this fact, some physiologists have gone so far as to say that the ingress of coal-dust into the innermost structures of the lungs is a physical impossibility. It is of no avail, however, to raise a theoretical objection to the possibility of the existence of a known fact; and the undoubted fact is that fine coal-dust has been found both in the finer air-tubes, and in the air-cells of the lungs. The most reasonable explanation of this fact is, that, though the cilia do naturally present a certain amount of resistance to the passage of the coal particles, yet by the constant in-coming of these particles the cilia may be tired out, and so be unable in the long run effectually to oppose their progress. Further, the cilia are very fine hair-like bodies, and their tender structure may easily be damaged, and the cilia themselves even carried away, by the close and heavy coal-particles. In this way, then, the particles of coal-dust find their way into the lung-tissues, and when there, set up spasm, tightness, difficulty of breathing and cough with expectoration, in the manner explained in a former chapter. It may be said generally here, as there will be occasion to refer again to this point more than once in the course of these chapters, and as it is desirable to avoid repetition, that mineral dust acts always in the same way, whether it be dust from wool, or from coal, or from glass or potter's clay, or from jute or cotton, and that it sets up the symptoms already described, and which it is therefore unnecessary to repeat.

What is called "miner's lung" is caused primarily by lodging of this coal-dust in the cellular portion of the lung-tissue. It acts there as a foreign body, and sooner or later sets up softening and disintegration of the lung-substance. Masses of dust can be seen on cutting into the lungs of persons so affected. These masses cut gritty against the knife, or sometimes like india-rubber, and are found to consist of dust and lung-tissue mixed up, or sometimes they are found in the bronchial glands which exist in the roots of the lungs. Wherever they are, they set up inflammation of the surrounding lung-tissue, and by-and-by softening and breaking down of the tissue. In the last case we have a common form of consumption. In many instances there is found a deposit of what doctors call tubercle, along with the deposition of the coal-dust, and then the disease runs a more speedily fatal course than when it is due to coal-dust alone. In cases of common consumption this tubercle, which consists of yellow or grey ill-formed cells, is found dotted up and down the lungs, and either acts as a centre from which inflammation and softening may spread, or is itself deposited as a secondary result of previous and repeated inflammatory attacks. Since it is sufficient of itself alone to cause consumption and death, it is not wonderful that when we find it along with the coal-dust deposits, the destruction of the lungs should take place more rapidly than when the dust masses exist alone. From this description it will be seen that what is called miner's lung is really a state of chronic recurrent inflammation, due to the breathing in of soot and coal-dust. This inflammation is followed by softening, and there may be associated with the softening a deposit of tubercle such as takes place in ordinary consumption, or this tubercular deposit may be absent.

The special affection of sight from which miners suffer is called Nystagmus. This is a Greek word, signifying originally nodding, such as occurs when people are drowsy; and the disease is so named because the eyes of the persons affected by it are in a state of continual movement. This movement may be from side to side (oscillation), or up and down (nodding), or round and round (rotation), or

lastly, the movements may be in an oblique or diagonal direction. In any of these cases the sufferer is prevented from seeing objects steadily because the movement of his own eyes causes a sensation as if the objects looked at were dancing up and down, or from side to side, or round and round, and it so appears unsteady. A large number of miners suffering in this manner find their way to the Bradford Eye and Ear Hospital, and there I have seen a good many of them. The miner can generally steady his eyes when looking at the floor; but directly he moves them up to look at an object straight in front of him, or between the horizontal position and the floor, his eyes begin to oscillate, and the object appears unsteady. The oscillation increases when the patient tries to look upwards. The walk of persons suffering in this way is peculiar, as they are obliged to keep their eyes fixed on the ground, and cannot look straight forward without shaking. They complain that they cannot see to do their work in the pit, and that on going into a room lighted by gas their eyes dance about until they get used to the light.

The cause of this curious affection is twofold, arising in a small part from the position of the miner's head as he lies on his side at work; but the chief cause is the dimness of the light in which he works. The reasons which have led to this conclusion are the following:—Nystagmus is an affection not confined to miners—indeed it is only of late years that oculists have recognised miner's nystagmus as a separate variety of the disease. As usual, there is a dispute as to who first drew attention to it, but it is certain that, so long ago as 1858, a patient suffering from miner's nystagmus was admitted to the Bradford Eye and Ear Hospital, and that a few years later, the surgeons of that hospital had recognised that miners were always the subjects of this form of the disease. Now ordinary nystagmus, when it occurs, is very frequently associated with some cause, interfering with distinctness of vision. It very frequently follows inflammation of the eyes in very young children, thus causing opacity of the outer coatings of the eye, and preventing the entrance of sufficient light. It is found also when cataract is present in early life, and is common also in albinos. Now in all these cases the image formed on the retina is dimmer than usual, and hence as the dim light of a coal pit is not compatible with distinctness of vision, it is probable that the disease is largely dependent on that cause. Even if the miner could stand to his work, as is possible in a seven-foot coal seam for instance, this cause would still come into play, but the vast majority of seams are much thinner than this, many of them being only from two to three feet thick; hence the dimness of vision inseparable from mining is aggravated by the straining of the eyes, when a miner lies on his back or side to work a seam of this thickness. The last piece of evidence in favour of this view is the fact that the only satisfactory method of cure for miner's nystagmus is found in removing the operative from the dimly-lighted workings, and placing him at rest above ground for some time. When the workman is beginning to recover, he can raise his eyes up to the horizontal position without oscillation. Ability to look his interrogator full in the face marks a stage towards recovery, and as time goes on, if rest is possible, it is found that he can raise them higher and higher without rolling. Of course a return to the old conditions speedily reinduces the affection, and hence one reason for the demand for work above ground, though positions of this kind are often less highly paid than those in the pit. I know of no statistics to show in how large a proportion of miners this disease occurs, but judging from the comparatively small number of admissions to the Bradford Hospital, where, nevertheless, the subject has received at least as much attention as anywhere else, I am of opinion that the number of men who suffer must be small.

The last set of disorders I shall mention from which miners suffer is general stunting of the development of the body, due to setting about their work at too early an age, and the hardness of the work to which they are subjected. Even a non-medical observer who sees miners going to or returning from their work, cannot fail to be struck by the badness of their walk. I have no wish to be offensive to this hard-working class of people, far from it, since the defect of which I am speaking is due to no fault of theirs, but the simile, which has often forced itself on my mind in watching miners walk, is one made classic by Homer when he refers to the gait of cows, and calls them *rolling-footed* or *rolling-limbed.* "Shauchle-footed" is the expressive Scottish equivalent for that sort of gait in which the legs do not appear to be under sufficient control. This rolling walk is due to the cramped position the miner is compelled to maintain at work when he is coal-cutting in narrow seams. But a still more powerful cause is the fact that a boy who commences coal-getting is often set to push with his head corves loaded with coal along the rails leading to the bottom of the shaft. The

men fill the corves, or little wagons, and the boys push them with their heads while creeping on their hands and knees. The immediate effects of this practice are two—first, that the head has not freedom to expand to its natural size; second, that the top of the head is very often made bald even in youth, or at least, that the hair grows in a very spare and imperfect manner. The remote effects of thus preventing the free development of the head are, stuntedness and want of growth in the body generally; and hence it is not uncommon to see in the out-patients' room of hospitals miners of twenty years of age who look not more than fourteen or fifteen; while many of them have bald patches on the top of their heads, with a dry scaly condition of the skin in that region. Pressure on the head prevents the growth of the brain and the other nerve centres, and the arrest of their development interferes with the growth of the limbs by impairing their nervous supply. When this has continued up to eighteen or twenty years of age, of course the condition is past remedy.

As to prevention, there is not much to be said. The diseases of the lungs from which miners suffer must, I fear, always continue to a greater or less degree. The damp and darkness of coal-mines are conditions both of which are unfavourable to health, and they seem inseparable from mining. The inhalation of soot and coal-dust might be somewhat lessened by the use of respirators. The nystagmus, being due to insufficiency of light, seems also to be inseparable from the occupation. Should it ever prove possible or safe to light mines by electricity, this might diminish the nystagmus; but at present the probability of explosion by fire-damp offers an insuperable obstacle to the carrying out of any such suggestion. As regards the last-named condition from which miners suffer, there seems to me to be no sufficient reason for its continuance. It would surely be quite easy to attach a rope to a set of corves full of coal, and to draw them to the shaft bottom by means of the steam engine which in most mines works the cage. This would obviate the necessity at present laid on the miner of pushing them with his head. The law which prohibits the entrance into mines of boys under thirteen years of age has been most beneficial in its operation. The head, however, continues to govern the growth of the body after thirteen, and indeed on to twenty-one years of age, and it is therefore to be hoped that the introduction of the simple mechanical contrivance suggested may speedily put an end to this remediable class of diseases from which miners suffer.

COTTON.—XXII.

CALICO PRINTING: ITS EARLY HISTORY AND DEVELOPMENT—BLOCK PRINTING—INVENTION OF THE CYLINDER MACHINE.

By David Bremner, Author of "The Industries of Scotland."

We now come to that highly interesting department of the cotton manufacture which deals with the embellishment of the cloth with coloured devices, and is described in a general way as calico printing. At a remote period in the history of the industrial arts, dyeing and painting linen and cotton fabrics were practised in the East. Referring to the customs of a people who lived on the shores of the Caspian Sea, Herodotus says:—"They have trees whose leaves possess a most singular property; they beat them to powder, and then steep them in water. This forms a dye, with which they paint on their garments figures of animals. The infusion is so very strong that it cannot be washed out; it appears to be interwoven in the cloth, and wears as long as the garment." The flowered cottons of India are mentioned by Strabo as being famous in his time—two thousand years ago. Pliny gives a description of the Egyptian mode of dyeing or staining cloth with the aid of mordants, which shows marvellous progress for the time. He says:—"Garments are painted in Egypt in a wonderful manner, the white cloths being first smeared, not with colours, but with drugs which absorb colour. These applications do not appear upon the cloths, but when the cloths are immersed in a cauldron of hot dyeing liquor, they are taken out the moment after painted. It is wonderful that although the dyeing liquor is only of one colour, the garment is dyed by it of several colours, according to the different properties of the drugs which have been applied to different parts. Nor can this dye be washed out. Thus the vat, which would doubtless have confused all the colours if the cloths had been immersed in a painted state, produces a diversity of colours out of one, and at the same time fixes them

immovably." The designs were in those early days, and indeed until a comparatively recent period, drawn upon the cloths with pencils or reeds, the more expeditious process of block printing not being known.

At what period the art of calico printing—or rather painting—was introduced into Europe is not exactly known; but it is not believed to have been before the beginning of the seventeenth century. Anderson, in his "History of Commerce," states that calico printing was first practised in London in the year 1676. Another authority fixes the time about fourteen years later, and says the first print-ground was established at Richmond, by a Frenchman. When a duty on printed and dyed calicoes was imposed in 1712, the most important print work in the country was at Bromley Hall in Essex.

About the time the trade was introduced into England, a demand sprang up in the country for the dyed and printed calicoes of India, China, and Persia, and home products of all kinds for which these were substituted could not be sold. This led to an agitation on the part of the woollen and silk manufacturers against the fashion and its encouragement by the Government; and the result was that in the year 1700 an Act was passed prohibiting the importation and use of Eastern prints under severe penalties. The home producers of printed calicoes profited by this enactment, and gradually extended their operations, until by the year 1712 their productions were considered worthy of the patronage of the Government in the shape of an excise duty of 3d. per square yard of calico "printed, stained, painted, or dyed." This imposition did not interfere with the progress of the trade, and on observing this, the Government doubled the duty in 1714. For some reason printed linens were more leniently dealt with than the cottons, only half the duty being exacted on them. The printers improved their designs and processes, and found a ready market for their goods. The latter fact once more raised the voice of complaining on the part of the woollen and silk manufacturers. The aid of Parliament was invoked, and, strange to say, a law was passed in 1720 prohibiting the use or wear of any printed or dyed calicoes whatsoever, whether printed at home or abroad, and even of any printed goods of which cotton formed part; excepting only calicoes dyed all blue, and muslins, neck-cloths, and fustians. The printing of linen was not interfered with. After being in operation for sixteen years, the Act was modified so far as to allow the use or wear of printed goods of a mixed kind containing cotton. Cloths composed of linen warp and cotton weft were then printed and sold in considerable quantities. The prohibition as to printing and weaving cloths made entirely of cotton was continued till 1774, when they were allowed to be printed on payment of an excise duty of 3d. per square yard. This duty was subsequently increased by fifteen per cent. by additions made in 1779 and 1782. When the drain made by the American War on the finances of the country came to be met, Mr. Pitt laid his hand heavily upon the bleaching, dyeing, and printing trades. All engaged therein had to take out licenses, while a great increase was made in the tax on the goods they dealt with. The effect of these impositions was to excite great alarm and discontent in the cotton manufacturing districts, and it was represented to the Government that they would inevitably result in crushing one of the most promising branches of industry. So urgent was the appeal made to him that Mr. Pitt gave way, and repealed the new duties. The event was celebrated in Lancashire with much rejoicing, and when Mr. Thomas Walker and Mr. Richardson, who had been especially active in the application to Government, returned from London, they were honoured with a triumphal entry into Manchester, being met by a procession, which extended nearly from that town to Stockport. Silver cups were also presented to the delegates. A curious commentary on this demonstration is the fact that before the year was out, increased duties were imposed on all printed goods. When the Act for consolidating the customs was passed in 1787, the duty on printed calicoes was readjusted, and the rate then fixed continued in force till 1831, when the duty was entirely remitted. It may be mentioned here that in 1796, print duty was paid on 28,621,797 yards of British calicoes and muslins, and in 1829 on 128,340,004 yards. In the year before the duty was abolished it yielded no less a sum than £2,280,000, but of that only £350,000 went into the hands of the Chancellor of the Exchequer, the remainder having been returned as drawback on goods exported.

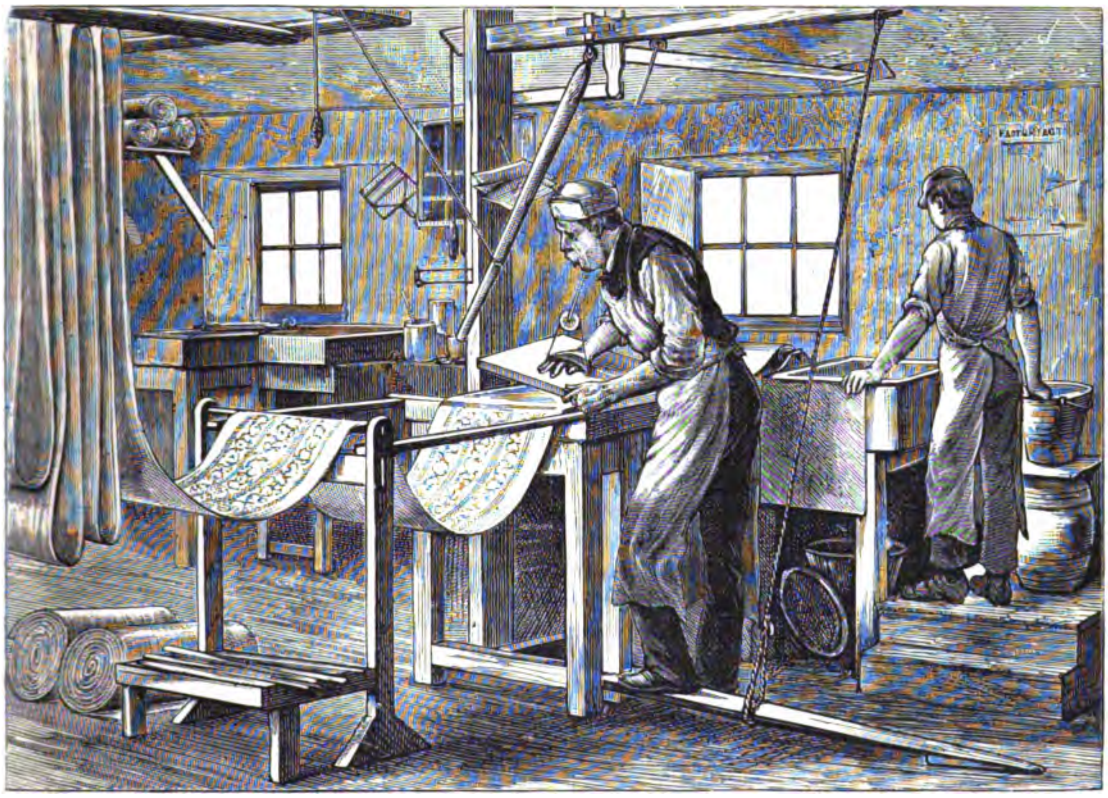
Up till the year 1738, when the art was introduced into Scotland, London and its vicinity was the chief seat of calico printing. Of the quality of the work done about the middle of last century we have the following testimony in the *Gentleman's Magazine* for March, 1754:—"Mr. Sedgwick, a very considerable wholesale trader in printed goods, had the

honour to present her Royal Highness the Princess of Wales with a piece of English chintz, of excellent workmanship, printed on a British cotton, which, being of our own manufacture, her Royal Highness was most graciously pleased to accept of. And on Sunday morning the said gentleman was, by Sir William Irby, introduced to her Royal Highness at Leicester House, and had the honour to kiss her hand, when her Highness was pleased to say that she was very glad we had arrived at so great a perfection in the art of printing, and that in her opinion it was preferable to any Indian chintz whatsoever, and would give orders to have it made up into a garment for her Highness's own wear immediately, as an encouragement to the labour and ingenuity of this country." When the Scottish and Lancashire men embarked in the trade, the London calico-printers found their occupation undergo a gradual decline, and this went on until it was almost entirely absorbed by their northern competitors.

Messrs. Clayton, of Bamber Bridge near Preston, were the first in Lancashire to engage in the business of calico printing, having in the year 1764 commenced operations on a small scale. At that time there lived at Cross, near Blackburn, a yeoman named Robert Peel (father of the first Sir Robert Peel), who owned and worked about forty acres of poor land. He was an active, enterprising man, however, and for the purpose of finding occupation for three of his sons, he procured a loom for each, and they devoted themselves to calico weaving, their workshop being in the farm-house. On one occasion a web was produced which was so badly woven that it could not be sold. Mr. Peel took it to Messrs. Clayton's works to have it printed with some device and made suitable for conversion into neckerchiefs. The price charged for printing was so high that Mr. Peel was led to consider whether the process could not be at once reduced in cost and its results improved. His deliberations led to experiments. Selecting as the figure for his first attempt at calico printing a leaf of parsley, he cut its outline with his own hand upon a block of wood. He then prepared his colouring matter, which he placed in a tub of convenient size. Over the surface of the liquid a woollen cloth was stretched, which on being pressed by the block, allowed an even supply to reach the surface of the latter. Placing his block squarely on a piece of calico spread upon a table, he struck it smartly with a mallet, and on raising it found he had got an excellent impression. By applying the block to fresh parts of the cloth he soon succeeded in covering its entire surface with the device. When the cloth was dry it was ironed smooth by his wife. So satisfied was Mr. Peel with the success of his experiments, that he resolved to embark in the calico-printing business, and with that object he removed to Brookside, a village two miles from Blackburn, where an abundant supply of water was to be obtained. With the aid of his sons he made a successful start, and soon the original establishment had to be greatly enlarged. The cotton-spinning and manufacturing concerns in which the Peel family were then also engaged progressed apace, Mr. Peel displaying great enterprise in adopting all the latest inventions introduced into the trade. In 1773, by which time the family ventures were in a very healthy state, the third son, Robert, who was afterwards created a baronet, retired from his father's concern and established himself, with his uncle, Mr. Haworth, and his future father-in-law, Mr. William Yates, at Bury, where, we are informed, the cotton-spinning and printing trades were carried on with great success. Mr. Baines says, "Mr. Peel, the father, with his other sons, and another Mr. Yates, established the print-works at Church, and had also large works at Burnley, Lalley Abbey, and Foxhill Bank, and spinning mills at Oldham, and afterwards at Burton-on-Trent, in Staffordshire. So widely did these concerns branch out, and so liberally and skilfully were they conducted, that they not only brought immense wealth to the proprietors, but set an example to the whole of the cotton trade, and trained up many of the most successful printers and manufacturers in Lancashire. The history of the two houses, the Peels of Bury and the Peels of Church, is indeed the history of the spinning, weaving, and printing in Lancashire for many years."

Reporting to the Society of Arts on the printed fabrics shown at the Exhibition of 1851, Mr. E. Potter gives the following particulars of the development of the calico-printing trade in the north of England:—"During the period 1796 to 1821, the Forts, Hargreaves, and Thompsons fairly established themselves as extensive and wealthy printers, not more by their energy and business talent than by their scientific attainments, and by the unbounded and lavish support which they gave to everything which art and science could suggest to assist them. Mr. James Thompson, of Primrose near Clitheroe, was for forty years the recognised head of the print trade. The era of his commencement in the trade

was the beginning of a series of discoveries and new applications in chemical science to the purposes of calico printing. During forty years he devoted himself and the ample funds his business placed at his disposal to the advancement of taste in connection with his trade. No sums, however large, were spared to draw into its service the talents even of Royal Academicians, and of many other eminent men high in art." Among others who contributed in an important degree to the advancement of the art may be mentioned Messrs. Hargreaves Brothers and Co., who produced several new colours and a great variety of styles, and Messrs. Thomas Hoyle and Sons, who invented a "madder purple," which by its fastness and brilliancy became extremely popular. During the last few years many improvements have been effected in the appliances of the trade, and novelties in colours and styles introduced.



Block Printer at Work.

Block-printing was a tedious and expensive process compared with the machine-printing of the present time. The blocks first used were of sycamore, and as they measured only ten inches by five, many applications were necessary to cover even a single piece of cloth. The pattern was engraved on the face of the block in such a manner that the impressions made by successive applications joined neatly and gave the design a continuous appearance. Owing to the softness of the wood and the rapidity with which it wore down, very fine lines could not be used in a design, consequently there was a lack of that delicacy of appearance which characterises more recently printed cloths. Many attempts were made to increase the productive power of the block, and also to render it more durable. The most satisfactory plan for meeting the latter requirement was the use of fillets of copper to form the pattern. These were obtained by flattening copper wire, and having been bent to the outline of the pattern drawn on the block, they were driven into the wood. Small spots were formed by using pieces of wire of various sizes and sections. This was a great advance, and opened a new field for the ingenuity of the designer. With the copper wire the most delicate lines and sprays could be produced, and when leaves or forms other than outlines had to be depicted they were readily formed on the block by making an outline

of the wire and filling it with felt, which in working gave all the effect of a wooden surface.

The appliances of the block-printer were few and simple, consisting of a table, a colour tub, and the block. The table was composed of a smooth stone slab covered with flannel. At one end of it a roller on which the cloth to be printed was wound, was mounted, and at the other some rods of wood were fixed near the roof, over which the cloth was hung to dry as it was printed. The printer stood at one side of the table, and at his right hand was the colour tub over which a boy known as the "tearer" presided. Prior to each impression the boy spread some of the colour evenly over a cloth stretched on an elastic bed in the tub. Dipping his block rapidly on two separate parts of the cloth thus prepared, the printer took up a supply of colour sufficient for one impression. He then laid the block upon the cloth, being guided as to its position by brass pins fixed in the corners of the block, and striking it smartly with a mallet transferred the colour to the cloth. With a block of the usual dimensions no fewer than 448 applications were required to complete a piece of cloth, and if two or more colours were used, the labour required was such as to greatly enhance the cost of the finished article. Another mode of block-printing is illustrated in the engraving on the preceding page.

We have spoken of block-printing in the past tense; but though it has long been virtually superseded by the cylinder machine, it is for certain purposes still retained. When the machine was invented and its merits came to be recognised, there was considerable agitation in the ranks of the block-printers. They had seen how people engaged in other departments of the textile manufacture had had their occupations destroyed by the introduction of mechanical agents, and dreading a similar fate, they opposed the use of the machine to the utmost of their powers. In 1815 the block-printers of Lancashire struck against the increase of machine-printing. They were paid three shillings for printing each piece of calico with three colours (of which sum the "tearer" got fourpence) and at that rate were able to earn from £2 to £4 per week. The same work could be done by the machine at one operation, in a fraction of the time, and at a cost of only fourpence per piece, so that the block-printers found themselves in the presence of a formidable rival. About that time, blocks faced with type-metal began to be used, and a mode of printing two or three colours from one block was devised. For certain kinds of work these were adopted, but the machines were gradually increased in number. Twenty years later we find traces of the old feud, and people arguing in favour of block-printing. To compete with the cylinder machine several forms of machines to print from blocks were invented and introduced to some extent; but these were not able to maintain a position in competition with the simple and expeditious cylinder-printer. They were, however, found suitable for printing felting and other heavy stuffs, and are now employed exclusively in that work. The best known of these machines is the Perrotine, so-called after its inventor, a Frenchman. Mr. Applegath also produced a block-printing machine, which met with some favour. There was a revival of block-printing in 1857, owing to the introduction of a variety of striped patterns which, after being printed on the machine, required to be filled in by blocks.

Printing from engraved copper or zinc plates was one of the early ideas for expediting operations, but it did not come into extensive use. The design for each colour was engraved on a separate plate, and the impression was taken off on a press similar to that used for ordinary copper-plate printing.

One of the grandest achievements in the history of calico-printing was the invention of the cylinder machine. It was a happy idea to have a cylindrical block that would move continuously over the cloth, and at the same time supply itself with colour. But it appears to have existed only in a crude form in the minds of the men with whom it originated. Just about the time that Wyatt and Paul were essaying the construction of their spinning-machine, a patent was acquired by two men named Keen and Platt for a cylinder printing machine. This was in the year 1743, and the machine is described as intended to print three colours at once, there being a separate engraved roller for each colour. There is not, so far as we have seen, any record of a machine having ever been made and got to work under this patent, and unless it contained some parts not mentioned in the specification, it is difficult to see how it could work effectively. The record of patents shows no further attempt to produce a cylinder machine until 1772, in which year one Atkins and others obtained a patent for a machine to print a single colour from a cylindrical block. The framing of this machine was of stout oak, and the printing roller of sycamore. In the lower part of the machine was a roller for supplying colour to the printing-roller, which was mounted immediately above it, and the cloth was pressed against the latter by a larger roller which occupied a position

on the upper part of the frame. But here, as in the case before mentioned, there is no testimony that the machine was ever turned to practical account.

The machine which may truly be said to have been the parent of cylinder-printing in the calico trade was that which was patented in July, 1783, by Mr. Thomas Bell, a Scotsman employed at Mosney, Lancashire. It is not known to what extent, if any, the inventor was indebted to a knowledge of what had been done by the previous patentees of cylinder-printing, but he has the credit of giving to the trade a machine that could not only be worked, but worked at an enormous advantage over hand-printing.

Bell's original machine, as depicted in the drawings accompanying the patent specification, so far resembled modern machines that the engraved rollers were arranged round a central pressure roller or "bowl," that each roller was supplied with a box containing colour, and that "doctors" were provided for removing superfluous colour from the rollers.

In its then form the machine cannot have passed out of the theoretical stage, for by the whole arrangement shown in the drawing, the surface of the pressure roller carrying the cloth must have travelled at several times the speed of the engraved rollers, so that printing would be quite impossible. This defect would soon make itself apparent to a practical mechanician, and was no doubt speedily remedied. The patent is dated November 12, 1783, and is entitled "a new and peculiar art of printing with one colour, or with various colours at the same time, on linnens, lawns, or cambricks, cottons, calicoes, and muslins, silks, silk and stuffs, and any other species or kind of linnen cloth or manufactured goods whatever." Bell is described as a copper-plate printer, and the nature of the invention is set forth in the following terms:—"It consists in the using for the purpose of printing as aforesaid, the machine or piece of machinery particularly described in the plan hereunto annexed, or hereunder drawn, and which machine or piece of machinery consists of the several parts, and is to be constructed, put together, and used in the manner described in the said plan, and the explanation subjoined thereto, and which machine or piece of machinery, and the rollers therein contained may be made of wood, copper, iron, pewter or any other kind of metal or material whatsoever that rollers are or can be made of. Different patterns may also be added to the rollers, which can be put on and off at pleasure." A second patent was obtained in the following year to cover some improvements, and protect a three-colour machine which Mr. Bell had devised. Two years later a third patent was taken out, and the machine was fairly started on its career of usefulness. The invention has been claimed for a French mechanician, but there is no evidence of the existence of a cylinder printing machine in France before the year 1801. During the last thirty years the calico-printing machine has undergone various modifications, and many changes and adaptations have been patented. Some of these provided for printing the cloth on both sides simultaneously, printing two or more colours from one roller, and so forth. In its essential parts, however, the machine remains as described in Bell's patents.

POTTERY AND PORCELAIN.—VI.

MAJOLICA—ENCAUSTIC, PLAIN, AND ART DECORATED TILES—MESSRS. MINTON, HOLLINS, AND CO.'S TILE WORKS.

BY JAMES FRANCIS McCARTHY.

MAJOLICA is one of the commonest descriptions of earthenware, and yet with it, by skilful formation and the judicious use of coloured enamels, articles ornamental as well as useful are constantly being made which, considering their relative cheapness, are marvels of industrial ingenuity, approaching, as they very often do, to a fair standard of art. Majolica, also known as *Faience* or Rafaelle ware, derives its name from the circumstance that in the twelfth century the Moors introduced from Majorca into Italy the manufacture of this kind of earthenware. Specimens of majolica produced at that time are not devoid of evidences of Oriental skill, but, according to some authorities, it was between the comparatively brief period of forty years—from 1520 to 1560—that the ware attained its highest perfection. This may be the *ipse dixit* of the *dilettanti*, but it would not be just to the industrial skill of this age to admit that the *dictum* in question conveys an absolute truism.

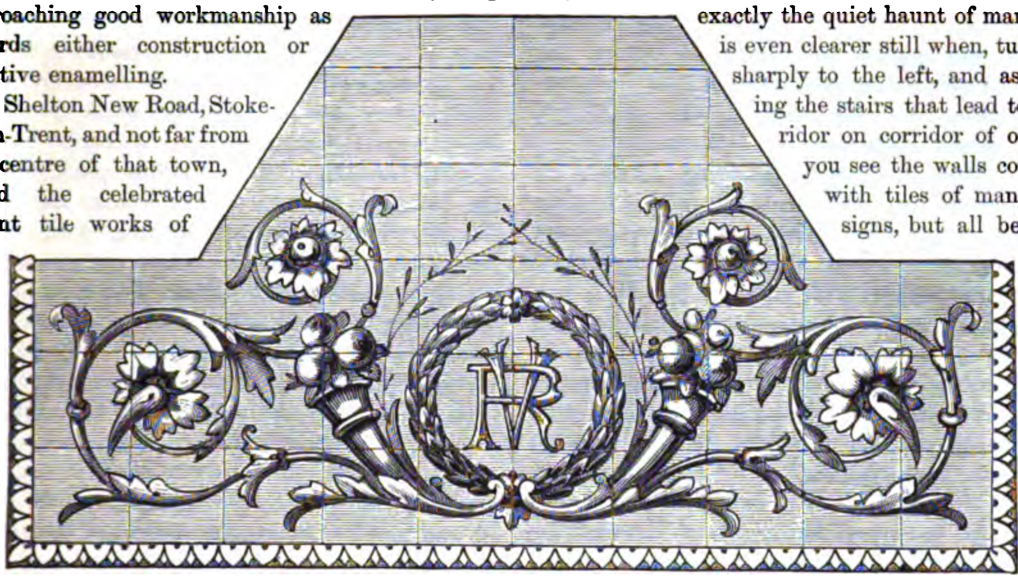
Undoubtedly, the classical designs of Rafaelle, Marc Antonio, and Giulio Romano in their day gave to this ware an exquisite beauty—perhaps such a grace as no artist of our times, by his own creation, can hope to rival. But, on the other hand, it must also be admitted that the skilled workmanship of the potter—perfected through ages of careful toil—has perpetuated this classical purity of treatment without deteriorating the original conceptions by feeble, meretricious, or slovenly imitation. Moreover, the result is enhanced by those mechanical agencies of the nineteenth century which give to the loveliest designs a finished realism that was unattainable in the earlier epochs of ceramic art. And when we consider ornamentation in connection with colour, the resources of chemistry, with the wonderful aid they give to manufactures, have enabled the potter of to-day to claim for the majolica he produces a marked superiority over that which was fashioned at the time when the genius of Rafaelle was unfolding to a wondering world higher and lovelier aspects of art. The majolica of the present day seems, therefore, to be as perfect as any that preceded it, which claims a sentimental admiration by reason of its antiquity; while for workmanship, as considered in the degrees in which it realises the designer's ideas, it is incontestably in advance of similar ware formed centuries ago.

Vase in Minton's Majolica.

The peculiar characteristic of majolica is that from a somewhat coarse foundation of plastic clay, covered with coloured enamels, a variety of articles, embodying really artistic designs, can be produced at a comparatively small cost. Both useful and ornamental ware is made of majolica, but the latter predominates. Of course, nearly every one is familiar with dessert dishes, plates, and other similar table appendages, of a variously-shaded green enamel. This is an instance of the useful class of majolica, but it is for ponderous articles of ornament that the ware is mostly brought into requisition. For large vases of exceptional size and abnormal decoration, for huge jardinières, colossal flower-stands, and for mighty imitations in clay of figures of men and animals, as well as mythological subjects, majolica is the general medium. The plastic clay from which it is formed is of the cheapest kind, and when compared with any other is of a much softer nature. The manner in which it is manipulated, except for the simpler class of ware, is principally by moulding, an operation which has already been explained. As applied to the construction of majolica, the process differs only in degree and not in principle. The larger articles in majolica of elaborate design have to be moulded in separate sections, there being in some instances as many as thirty, forty, and even fifty pieces. The designs are varied from perfect simplicity and purity of outline to the most fantastic and even weird conceptions of the artist striving to satisfy the insatiable demands of novelty. The result necessarily is that, interspersed with much that is really artistic in conception, there is a great deal of meretricious majolica. Probably the best effect is realised in the imitation of the classical designs, in which the figures selected from Grecian and Roman mythology are moulded in clay with a surprising gracefulness. Then, again, the ornamentation which consists in the representation of animals is excellent. At their works in Hanley, Messrs. Bromley and Adams have turned out several pieces of majolica ware in imitation of Landseer's lions. For perfect moulding, fidelity to the subject treated, skilled workmanship, and careful finish, through all stages and in every detail, they rank as remarkable specimens of art industry. The labour of moulding these heavy pieces is severe, and obviously occupies much time; while the firing in the "biscuit" state has to be most zealously regulated. It usually occupies about forty-eight hours for small specimens of majolica, and sometimes fifty-six for larger descriptions. After the biscuit-firing the enamel is applied by dipping the articles into it. Mixed with this enamel are the colouring ingredients, so that the firing which fixes the glaze also brings out the colours. These colours are of various tints, but the prevailing one is a variously-shaded green; while a very pretty effect is produced by blue and grey enamels. If the firing of the enamels is not very closely watched, the result, instead of being pleasing, is simply unsightly and disastrous. The colours lose their proper harmonising power, and, in cases where several are used, run into each other

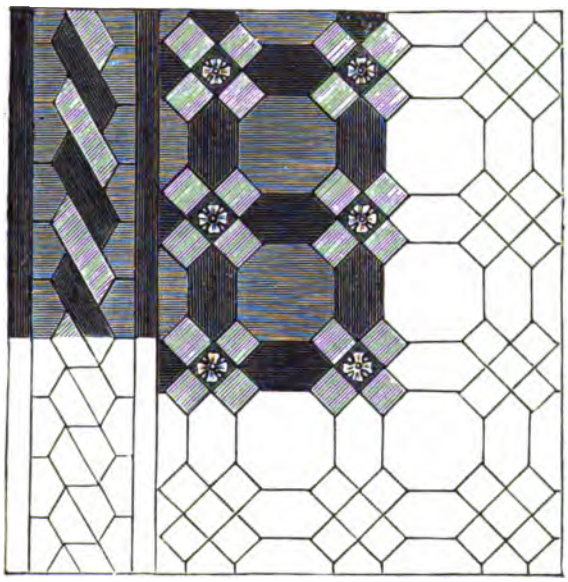
in a peculiarly unlovely manner. There is a good deal of common majolica, which can be obtained at a very slight cost, but it has no claim to anything approaching good workmanship as regards either construction or effective enamelling.

In Shelton New Road, Stoke-upon-Trent, and not far from the centre of that town, stand the celebrated patent tile works of



DESIGN FOR GLAZED TILE HEARTH. *(Scale, one inch to a foot.)*

Messrs. Minton, Hollins, and Co. The street lies near to the foot of a range of hills that run in an undulating line along the eastern side of the Potteries. The works occupy the greater portion of one side of this thoroughfare, and externally resemble something between a substantially-built school and a plain, unpretending chapel. But turning through a gateway, towards the end of the long block of clean red-brick building, the idea that you are entering either the portals of knowledge or the precincts of religious devotion cannot for an instant be entertained. These are but the offices of the firm, which shut out from the ordinary gaze the several square blocks of shopping which lie behind them. Each range is in itself a small works, but when viewed in conjunction with the others, when the throbbing of machinery is heard, and the hum of strongly-marshalled labour arises, and the great kilns on every side belch forth their inky billows of smoke, it is clear that this is not exactly the quiet haunt of man. It is even clearer still when, turning sharply to the left, and ascending the stairs that lead to corridor on corridor of offices, you see the walls covered with tiles of many designs, but all bearing as the central ornament the monogram of the firm. In every passage, at every turning, in every angle, and in every corner, they are still before you, and the floor on which you tread is inlaid with some of those famous encaustic tiles which, while recalling the classical tesselated pavement, remind one of the world-wide renown which their manufacture has achieved for Messrs. Minton, Hollins, and Co. The walls inside some of the offices are relieved with tiles, and on tables and mantel-pieces in odd corners you are confronted with these square slabs of clay; some, with their choice ornamentation, evoking admiration, others appealing to your ideas of neatness, and all reminding the beholder of the power and resources of the potter's art.* The business, which was established



DESIGN FOR TILE PAVEMENT. *(Scale, one inch to a foot.)*

* Through the courtesy of Mr. A. Mason, the commercial

in 1840 by the late Mr. Herbert Minton, and his nephew, Mr. M. D. Hollins, who is now the absolute proprietor of the place, was at that period very different to what it is now. Then the tile-making was carried on in Church Street, but owing to the development of trade and the popularity which the tiles attained, this place was found totally inadequate for manufacturing purposes. Then the existing building, covering an area of more than seven acres, and giving employment to eight hundred hands, was erected, with every facility, as will be shown, for conducting an extensive trade, and with sufficient resources, both manual and mechanical, to meet the most pressing demands of busy periods. For a long time, and until sixteen years since, the interests of the firm under notice were identical with those of Messrs. Minton, the no less celebrated manufacturers of porcelain. On passing through the large open space, on both sides of which are shops several storeys high, it will be noticed that there are fourteen firing ovens of exceptional dimensions, and there are six more at another works close by. Here, too, we catch a glimpse of the vast and ponderous machinery which gives motive force to this industrial hive, and entering the mills, we at once observe the large quantities of earthy material ready for pulverisation, or, with certain chemical ingredients, ready to be reduced into soft, moist clay. Farther on there stand heaps of plastic clay of various colours, according to varying requirements. Encaustic tiles are made from plastic clay composed principally of the same earthy and mineral ingredients as those used for other descriptions of pottery, with the addition, however, of china clay, which appears to enter into the composition of nearly every kind of tile. Passing out of the grinding mills, we are led into one of the encaustic tile shops, a rather lofty and well-ventilated room, about thirty yards long and nine wide. In the centre are long and high rows of shelving, looking very much like huge cupboards, the use of which will be presently explained. Before the long stretches of benches the tile-makers are at work. The pattern of the encaustic tile is first modelled in soft clay, and from this a second model, in plaster of Paris, which is solidified and hardened, and subsequently forms the working mould, is also obtained. The mould is enclosed in a square wooden frame of about the same dimensions as the tile, and a piece of plastic clay having been batted out is pressed to the mould. It necessarily copies the pattern of the tile and forms the basis of it. As the principle of encaustic tile-making is that the design shall be effected by fusion of colours, it is clear that the body of the tile, when it leaves the mould, must also permit of room for colouring matter. This is seen if the square piece of clay is removed from the mould, when the unfilled spaces, forming the indented outlines of the design, are traced. The mould, with the clay adhering to it, is then placed on a whirler, when the workman pours out of a can, as though it were oil, a liquid of the consistency of treacle, principally composed of clay, and of a chocolate tint in colour. This mixture, which in the present instance is being applied to tiles with a buff-coloured ground, runs into the hollow places; when this has dried, more colours are poured into other parts of the pattern, until gradually the whole of the surface is covered with it, whilst at the same time a piece of broad steel "levels" the thick fluid colour, that it may be evenly distributed and flow into every interstice. When the tile is dry, which will have taken about half an hour, the further process of "scraping" follows. This consists in another workman, who is next to the tile-maker, scraping the surface of the tile with a small metal plate, about four inches long by two in width. Shavings of a dark brown, flakey nature fly off. The colour is levelled down to the proper proportions of the tile, and in a few seconds the pattern is seen traced upon it. The tiles are then placed on the shelves mentioned, under which are stoves, and being submitted to a sharp heat are somewhat quickly dried; and finally, they are baked in the ovens. By the same process, it should be noticed, encaustic tiles of several or many colours can be made.

In the manufacture of plain tiles, and those which are "glazed" and decorated, pulverised or powdered, instead of plastic, clay is used. The idea of working with powdered clay, which, as will be seen, greatly facilitated the production of ordinary tiles, emanated, nearly forty years ago, from Mr. Prosser, a Birmingham machinist. It was improved upon by Messrs. Minton, Hollins and Co., who brought the process to a high degree of perfection. Before being pulverised the clayey and mineral substances are formed into soft lumps and dried hard. These pieces of dried clay are then broken and ground into the finest powder, which is afterwards sifted, so that it may be free from all gritty substances. It is then taken into the shop in which it has to be worked. It is

manager of this establishment, we were enabled to see the various processes in the manufacture of plain, decorated, and encaustic tiles.

placed in large bins, like those seen in bakehouses, and has the appearance of flour. At each side of the shop, which is not so large as the encaustic tile-making department, there are wooden benches, upon which rest at convenient distances "presses," precisely like those used for pressing metals, but with a wheel of about two yards in diameter, which, when sharply turned by an assistant, sets in action the piston over which it rests. The tile is formed by means of a hollow steel mould, or "die," of the dimensions and pattern required. The bottom of the mould is in a movable piece, while a small horizontal table surrounds the whole. To the bottom of the piston is attached a block, or punch. Some powdered clay, which has been moistened to give it cohesiveness, lies on the table; a quantity of it, sufficient to fill the cavity, is moved into the mould, the surface of which is cleared of superfluous powder. With the turning of the handle the piston has, with a regular and steady action, forced the punch into the mould; there is a slight hissing noise, caused by the air which has been pressed out of the powder, and when, by a reverse action of the press-wheel, the piston rises, there is a complete tile, of course in its soft condition, the bottom of which, as may be noticed, having plainly embossed on it transverse lines, with the name of the firm running across them. The pressure has been so great that the powdered clay has been condensed into a fourth of its original bulk, but still giving the exact thickness needed. Tiles by this process are made with extraordinary rapidity. One operative working at one press, and with the aid of an assistant, can stamp as many as a thousand tiles in a day. When it is borne in mind that at Messrs. Minton and Hollins's works there are more than sixty presses in daily work, how great is the rate of production can be readily imagined.

The smaller kinds of tiles are produced in a similar way, of course with a change of dies, but the presses are worked by women and girls. When the tiles leave the dies their surfaces and edges are smoothed with sand-paper, and after being examined for any defects, are dried, and then "fired" in the "biscuit" oven. Unlike ordinary pottery-ware, the firing of tiles is protracted, invariably lasting three days and three nights; and it should be noticed that tiles made by this process are not liable to that contraction by the action of the fire as are articles which are made of moist clay. For glazing purposes the tiles are dipped in silicious and other chemical mixtures. The firing in the "glost" oven is also prolonged; and lest the tiles should split into pieces by speedy withdrawal from this oven, they are allowed to remain there to cool for three or four days.

With the evidence of the fact so constantly before us, it is almost unnecessary to say that the decoration and ornamentation of tiles have in these days reached such perfection as to come within the region of high art. While there is much meritorious decoration produced by the printing process, it is in painting on china tiles, used for various purposes of ornamentation, and on fancy hearth-tiles, that the most artistic effect is realised. The delicate and chaste painting on slabs of china is almost invariably performed by ladies with a skill which compares favourably with similar, and much more pretentious, work on canvas. The painting of costly tiles—tiles which form bright pictures of the hearth that do not readily fade—is always effected in their biscuit state. These tiles are passed into the department of the artists, and these gentlemen place them upon their easels, and with the colours which have been so carefully prepared transform the plain squares of clay into lovely pictures. The firing necessary to indelibly fix the colours lasts many hours. The tiles, after firing, are returned to the artists, who in putting the several pieces together can observe the general effect of their work, and very pleasing it is. For instance, at one end of the long room sacred to the artist's fancy, may be found a series of tiles illustrative of horses' and dogs' heads. They are drawn with such breadth, vigour, faithfulness, and animation, as to recall the skill of Rosa Bonheur. Farther on, may be seen tiles representing birds of many-hued plumage, which testify to the marked care with which the painter has portrayed these bright-winged creatures. At the other end of the room there are tiles treated in a conventional manner; whilst in the middle of the place there may be noticed a large number of pieces, perhaps more than forty, of tile-work, which when they are fitted up in the destined fire-place will indeed beautify that hearth. The central design is a group of rose-leaves—every blushing petal being minutely figured—with a border of dead leaves, the flowers being painted as only true artists can render them. When finished, the tiles are taken to the large warehouses, and there they are stacked in tens of thousands.

FOREIGN RIVALRIES.—XI.

WOOD-WORK AND LEATHER-WORK.

By H. R. Fox Bourne.

It is not always disadvantageous for a nation, any more than for an individual, to be worsted in competition with others. It may even be greatly to our profit to have to abandon callings and pursuits which we formerly found very serviceable and to which we are still inclined, on its being proved that they can be better followed by others than by ourselves, and if we are thus left free to take to more suitable occupations. Hence we may look with far more equanimity on the signs of decline in English pre-eminence in the industries connected with wood-work, and yet more with leather-work, than on the warnings of our deterioration in other trades, which are of more vital importance to us.

Timber, it need hardly be said, is generally only a real source of wealth to poor and sparsely populated countries. We have good reason to be proud of the forests and smaller plantations in which our oaks, and other stalwart trees, still flourish, and on every ground—for hygienic as well as for commercial reasons—we may hope that they will continue to be cultivated, at least as plentifully as they now are. But it is no loss to us that our country ceased many generations ago to export its timber in any quantity, and we need not dread the almost certain prospect that is before us of losing at any rate a large share of the import trade in this class of commodity which we have for some time enjoyed. We ought not to grudge the peoples of Northern Europe and America the benefits they derive from their interminable forests of pine and other woods, or the inhabitants of more southern parts their gains from traffic in such costlier products of the soil as mahogany and ebony, seeing that among us wood-cutting has given place to more profitable occupations like iron-working and cotton-spinning; and we can better afford that they should outstrip us in much of the workmanship in wood for which we are still famous, than that they should surpass us in some of the other trades in which we now excel. It is in the nature of things that, as civilisation and local enterprise advance, cumbersome materials like timber should not only be worked up for home use near to the districts in which they are found, but also be there manufactured into such finished articles as can be most conveniently and cheaply transported to the markets for which they are available.

It is strange indeed that the United Kingdom should still import so much timber as it does. The quantity of native produce has perhaps not varied greatly during the last fifteen or twenty years, but the importations of hewn, sawn, and split wood had steadily risen from about 3,630,000 loads, valued at £11,528,000 in 1862, to about 6,670,000 loads, valued at £19,040,000 in 1877. This increase, of course, is largely due to the recent growth of our ship-building trade, in spite of the great fluctuations it has lately undergone, and the vast changes wrought by the use of steam and iron, which might be thought injurious to the older trade in more entirely wooden ships. The number of our sailing vessels had certainly been reduced from 26,339 in 1863, to 21,169 in 1877, and their aggregate tonnage from 4,731,217 to 4,260,699; but during the same period the number of steam vessels had increased from 2,298 to 4,564, and their tonnage from 596,856 to 2,139,170, showing altogether a gain in carrying powers of twenty per cent. during the fifteen years. We now construct fewer vessels in a year than formerly, either for our own merchants, or for foreign customers, but those we turn out are of much larger aggregate bulk, and, notwithstanding a few murmurs to the contrary, there is small risk of "British-built" ships losing their superiority over all others.

Whether we shall maintain our character for excellence in other sorts of wood-work may be doubted. English carpenters used to be famous for the deftness and thoroughness of their work, but it must be admitted that, in common with the other building trades, they have lately done much to prejudice themselves, and it is not satisfactory to know that from the United States every year there now come even into England great cargoes of window-sashes, doors, skirting-boards, panel work, wainscots, and all kinds of joinery, which, as wood is there much cheaper and labour no dearer, can be sold at a profit over the heads of our own workmen. The Americans are also sending furniture to us instead of coming to us for it, as the cheap and comfortable "American chairs," now to be found in nearly every house, testify. The value of the household furniture exported from the United States in the year ending June, 1878, a large quantity of which was disposed of in England,

was nearly £400,000, or £50,000 more than in the previous year. Our own exports under that head, including the large item of "upholstery wares," with which wood-work has little to do, amounted to only about £380,000, and was below the average of the past five years. With foreign countries we have never had much trade in furniture; but we used to supply our colonies with nearly everything but the rougher articles that they made for themselves. They are now learning to make fine as well as rough articles at home. We have no reason to complain at this sign of their progress, but it is worth noting.

In leather-work, both where it is mixed up with wood-work, as in furniture and in other branches, the decline of our colonial trade is yet more marked. The heavy protective duties imposed by them seem hardly needed to encourage the enterprise in tanning and almost every kind of leather manufacture that is showing itself in nearly all our great colonies and dependencies. The exports of leather from Canada, for instance, rose in value from £34,409 in 1872 to £150,201 in 1877 (having, indeed, amounted to £230,412 in 1876), while its imports sank during the same six years from £357,634 to £281,780. Victoria, which in 1862 imported boots and shoes alone worth £767,683, spent in 1876 only £200,040 in supplying the deficiencies of its local industry, while its exports of leather rose from £30,857 in the former year to £196,117 in the latter. Those figures show why, being glad to send to England and elsewhere 165,399 hides, worth £116,142 in 1862, its tanners and leather-workers had only 3,323 hides worth £2,996 to spare in 1876. The supply of the raw material had been just doubled in the interval, but nearly all was absorbed in profitable manufacture at home for the almost doubled population. In New Zealand, again, though its foreign trade both in raw hides and in manufactured leather is insignificant, whereas £177,531 was spent in importing boots and shoes in 1862, no more than £135,491 was thus required in 1876 by a population that had quadrupled in the interval. On the other hand, the younger colony of Queensland increased its imports of boots and shoes from £57,965 to £117,261, and its exports of hides and skins from £20,550 to £79,658, during the same seventeen years, though there was evidence of the growth of native industry in the fact that, requiring saddlery and harness worth £27,167 and other manufactured leather worth £57,955 in the earlier year, it required in the latter only £29,893 worth and £12,008 worth of those commodities respectively. Manufacturing enterprise, as in the sister-colonies, is following in the wake of pastoral and agricultural progress.

That the most prosperous of our colonies should thus be learning to prepare their own leather, and make it into such articles as they require, whatever may be the effect on our home industries, is not a matter for regret when the general interests of the whole empire, and all English-speaking races are considered. We have more reason to be jealous if we find that nearer and more avowed rivals are robbing us of our trade under conditions far more injurious to us, and for which we may have ourselves chiefly to blame. It is true that in our entire export trade in boots and shoes there has been no very great falling off as yet. In spite of the reduced demands from many of our colonies, others, like the Cape of Good Hope and Natal, and yet more the new markets we have opened up in Brazil, and other parts of South America, have kept our shipments at nearly the same level, the exports being 447,979 dozen pairs, worth £1,637,550 in 1862, and 404,135 dozen pairs, worth £1,484,421, in 1864, while in 1877 they were 436,166 dozen pairs, worth £1,336,478, showing a much greater decline in value than in quantity. But our manufacturers now have to face an import trade hardly dreamt of until a few years ago, and threatening them with serious competition, even in the home markets. In 1871 we imported 44,229 dozen pairs, worth £138,394. In 1876, only five years later, the numbers had risen to 109,906 dozen pairs, and the amount to £328,540. Of that quantity more than three-fourths came from France, and about an eighth from Germany, while neither country took any from us in return. Thus already nearly a fourth of our export trade is neutralised, and the great manufacturing firms in Northampton, Leicester, Norwich, and elsewhere allege, with some appearance of truth, that the damage now being done to their trade is only the beginning of a far worse state of things. It is clear, however, that their condition would be in no way improved by yielding to their demands for a protective duty on the foreign goods brought into the English markets. Such a duty would only divert the French exports from England itself to its foreign customers. So long as leather is cheaper in France than in England, and labour no dearer as well as more manageable, the French, if prevented from making boots for Londoners will make them for Brazilians. All that it becomes us to do is to see whether we cannot so improve our conditions of

boot-making as to hold our ground against our rivals; if we cannot do that, we must set ourselves to find sufficient occupation in other branches of the leather trade, or in other industries than those connected with leather.

In glove-making, French and other foreign competition has always placed English workmanship at a great disadvantage; but, with that exception, it must be admitted that the boot and shoe trade furnishes the most extreme instance of the rivalry to which, as regards leather-work, our manufacturers are now exposed. There is nothing very alarming in the statistics of our leather industries generally. Whereas in 1863 we paid £2,183,141 for the 745,601 cwt. of tanned and untanned hides of oxen, horses, and other animals, which we imported, we could afford to pay, at a much higher rate, £4,668,261 for 1,127,480 cwt. in 1877, and our imports of sheep, lamb, and goat skins had risen in value during the same period from £566,780 to £2,152,407. We had continued to tan most of the former to be used in saddlery, and other trades as well as boot-making, for ourselves, and though we have always chiefly availed ourselves of the more delicate work of foreign tanners and curriers in preparing the softer skins for use, there had certainly been no decline in this industry among us. Of both classes of material, by far the larger part was for home use. During the fifteen years, however, the leather that we had tanned, but not otherwise worked up for exportation, had more than trebled in quantity, and had advanced in value from £440,797 to £1,165,134, while our shipments of saddlery, harness, and other wrought leather, exclusive of boots and shoes, had increased from £486,757 to £657,377. If these figures do not represent industries of the first importance, they show that the industries, though more progressive abroad, are not at present dying out in England.

By way of compensation for our losses, actual or relative, in the working up of leather, moreover, we may take credit for our recent gains in the manufacture of other articles which in their use, though not in their origin, are sufficiently akin to leather for brief mention of them to be allowable in this chapter. The history both of india-rubber or caoutchouc and of gutta-percha notably illustrates the success with which, if the proper enterprise is shown at the right time, our manufacturers can profit by new trades when old ones begin to fail.

The popular name of caoutchouc points to the use first made of it. "I have seen," wrote Priestley in 1770, "a substance excellently adapted to the purpose of wiping from paper the marks of black-lead pencil. It must therefore be of singular use to those who practise drawing. It is sold by Mr. Hearne, mathematical instrument maker, opposite the Royal Exchange. He sells a cubic piece of about half an inch for three shillings, and says it will last several years." For some time after that, this curious vegetable juice continued to be rather a costly toy than an important article of commerce. As early as 1791, Samuel Peal took out a patent for its application to waterproofing purposes; but this process was hardly successful until Thomas Hancock, afterwards the leading member of the firm of Macintosh and Co., began to improve upon it in 1820. A series of useful inventions followed, and a great trade grew up, to be increased by the introduction of vulcanised india-rubber, by Mr. Walter Hancock, in 1844, and by such later novelties as vulcanite and ebonite, by means of which caoutchouc is now enabled, in certain ways, to take the place not only of leather, but also of wood, bone, pottery, and other commodities. Our imports from Brazil, Bengal, and Western Africa amounted to 45,039 cwt., worth £351,555, in 1863, and they had risen to 95,642 cwt., worth £1,086,540, by 1871, when there were in England and Scotland 39 principal india-rubber factories, employing 5,745 hands. Since then there has been no great advance, and, as might be expected, the Americans are endeavouring to outdo us in this trade, but it is not likely to decline as long as the fertility of resource hitherto shown in it is maintained.

Gutta-percha appears to have been known in Europe even earlier than caoutchouc, but very little notice was taken of it before 1842, when Dr. William Montgomerie brought samples from Singapore, and pointed out the many uses to which it might be applied. So sudden was the demand that arose that by 1847 nearly all the trees yielding the peculiar juice in Singapore had been cut down, and supplies had to be sought from other parts of the Straits Settlements, which exported about 40,000 cwt. in 1857, and 90,000 cwt. in 1877. Of that quantity about half comes to England, which consumed 21,655 cwt., worth £224,961 in 1863, and as much as 54,898 cwt., worth £479,316, in 1873. Useful as this substance is, its applications are not as various as those of india-rubber. Its special value consists in its furnishing a particularly appropriate material for surgical and other scientific

instruments, and for the covering of telegraph wires. If such discoveries as Mr. Bell and Mr. Edison—the former with the telephone, the latter with the phonograph—have startled us with continue to be made, and can be proved to be really useful to the world—as to which no one entertains the smallest doubt—the gutta-percha and india-rubber trades will profit immensely.

IRON AND STEEL.—XXII.

BIG GUNS.—SECOND PAPER: THE MATERIALS.

By William Dundas Scott Moncrieff, C.E.

It was shown in the chapter upon the history of big guns (Chap. XXI.) that improvements in their construction have closely followed the development of the metal trades. First of all they were made of bronze, because a knowledge of the processes necessary for its production preceded the discovery of gunpowder, and was at once available for the purposes of artillery. So soon, however, as sufficient skill had been acquired in the manipulation of wrought iron as to render it practicable, the blacksmiths of the Middle Ages turned their attention to this material, and the gigantic pieces of ordnance previously referred to were the result of their labours. Even when the greatest care was bestowed upon their construction they were liable to accidents, and the Governments of these early days were therefore eager to discover some other system, not only on this account, but with the object of avoiding the costliness of malleable iron guns as well. The art of casting in iron, which had already made considerable advances in France, was developed in England during the reign of Henry the Eighth by a Frenchman, named Peter Baud, whose labours have already been spoken of, but in this country at least the Government was almost wholly dependent upon private enterprise for its supplies of artillery until the close of last century.

But although this country had become possessed of a national arsenal, it was many years before anything approaching to a perfect system was introduced as a substitute for castings of iron and brass. It appears strange that a knowledge of the scientific principles upon which the construction of big guns ought to be conducted, and upon which their safety altogether depends, should never have been acquired until very recently, and the more so, as an acquaintance with the structure of iron and the manner in which it is affected by the processes of manufacture is really all the information that is necessary. Even now, though iron is employed so universally for the every-day purposes of life, there is a great amount of ignorance of the principles upon which it ought to be manufactured.

It may be said that the difficulties which our armies had to overcome at the siege of Sebastopol, in throwing shells into the city from a distance that had never previously been contemplated, led to efforts on the part of our home Government which were not only followed by great improvements in the construction of artillery, but by the discovery of the principles which it is one object of this chapter to explain.* It is to Mr. Robert Mallet that the chief credit for these advances is due, and it is upon his scientific labours that the practical construction of the Fraser guns, generally known as Woolwich Infants, is based.

In many great industries the raw materials with which the manufacturer has to deal come to his hands as nature made them, and his business is simply to convert them into marketable commodities. This is the case with the textile industries that form so large a part of our trade and national wealth. The fibres from which cotton cloth is woven, or the hairs of woollen fabrics, however they may be treated by cleansing and spinning and weaving, remain unaltered as far as their own nature is concerned. It is different with the fibres of iron. The stability of an iron structure depends just as much upon the strength of the fibres of which it is composed as the durability of a piece of cloth depends upon the strength of its threads. Not only is this the case, but just as a piece of cloth is capable of bearing a great strain in one direction, and a very small one in another, so is a piece of iron. The great difference between the two materials is, that while the fibres of the cloth

* "The necessity for increased range for siege-artillery," writes Mr. Mallet, "was first rendered evident at the bombardment of the Fort of Matagorda when bombarded by the French from across the estuary at Cadiz—a range not before achieved. It was attained there by lead-loaded shells thrown from the howitzers now in St. James's Park."

remain the same, the fibres of the iron are very readily affected by the processes which are necessary for converting it to useful purposes. The essential conditions referred to are heat and pressure. Now, until Mr. Robert Mallet studied the subject we were practically in the dark as to how iron was affected by these two conditions, and the consequence of this ignorance led to a great many accidents, the wonder being that there were not a great many more. In the case of a woollen fabric, it is very easy, with the aid of a magnifying glass, to trace all the details of the structure. It is quite possible to find out whether or not the threads have been uniformly spun and received just the proper amount of twisting to give them the greatest strength, and an expert is equally well able to judge of the quality of work in the weaving. In iron no such means of ascertaining its internal structure are available, and it is therefore necessary to fall back upon a knowledge of cause and effect, and in this way, knowing that certain causes will produce certain effects, avoid everything in the construction of a big gun which we know will have the effect of making it weaker, and do all those things which we know, from previous experiment, will make it stronger.

Taking the analogy of a piece of cloth once more, and referring again to the familiar fact that it will generally tear more easily in one direction than it will in another, a very good illustration of what happens to a piece of iron when heat is incautiously applied to it may be given by supposing that the piece of cloth when strained to its utmost in the direction of its greatest strength had its fibrous structure suddenly turned round in an opposite direction; the effect of this, of course, would be that it could no longer be strong enough to bear the strain, and would at once be torn to pieces. So far Mr. Mallet only took up the work of others, for many experiments had previously been made which showed that heat had an effect upon the structure of iron and other metals, but he was probably the first to state broadly the law upon which these changes depend. In a very general way, it may be said that the *direction* which heat takes either in entering or leaving a crystalline body, such as iron, will be the direction which the fibres will ultimately assume when all the heat has left it; or, taking the illustration of the piece of cloth, if the heat followed the direction of its length, then, as in the case of the cloth, its greatest strength would be in that direction, and be capable of bearing a longitudinal strain, but if it crossed the cloth its greatest strength would be against a transverse strain, because its fibres would then lie in that direction. The fact of the cloth being a fibrous substance, and iron a crystalline one, renders this illustration not very suitable from a scientific point of view, but roughly it is sufficient to explain what really does happen.

The reader will now be better able to appreciate what amount of safety was likely to be obtained from a system of constructing artillery which ignored, because it was ignorant of, these important facts, and by which iron was treated almost as unwisely as if a rope were fastened along its side, and torn asunder by the strain, or as if a woollen or cotton manufacturer supplied his customers with felt instead of cloth.

But while the effect of heat upon iron and the manner in which it altered its crystalline structure was apparent, there remained the disturbing influence of pressure, which necessarily occurred in the process of manufacture. This is evident in many of the operations of the iron industry, and in none more so than that of rolling, which has already been referred to in a previous chapter. If a plate of zinc about one inch in thickness, which has been rolled, and has its greatest strength in the direction of its length, as in the case of a piece of fibrous wrought iron, is placed upon a red-hot plate, the heat passing through the thickness of the plate will have the effect of reversing the planes of crystallisation and turning them through an angle of 90°. The effect of this upon the metal will be to render it so brittle that a small fraction of the strain it was previously able to resist will be sufficient to tear it asunder. If the plate, however, were again heated and subjected to the process of rolling, it would be found that the fibrous structure had been restored to it, and that the crystals had been again turned through a further angle of 90°.

Mr. Robert Mallet, generalising from these facts, found that all we know of heat and pressure leads to the conclusion that the effects produced by these two forces are really dependent upon the same cause—viz., that the crystals arrange themselves in the direction of least pressure, which in the case of the rolling-mill will be at right angles to the pressure or along the length of the bar, and in the case of heat entering or leaving a piece of iron in the direction in which the heat enters or leaves it most readily.

It must now have become clear to the reader that an explanation of this somewhat obscure subject is necessary to an understanding of the

FIG. 1.

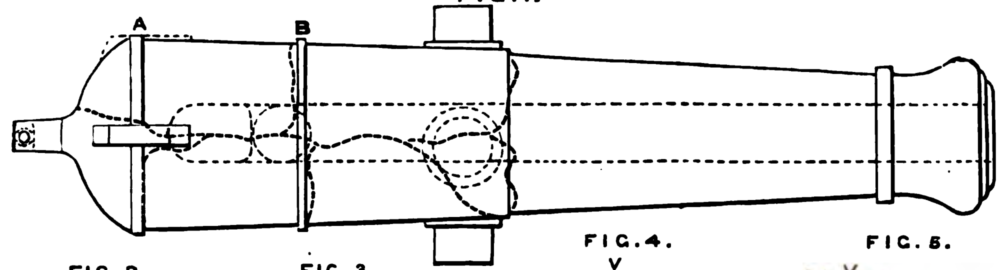


FIG. 2.

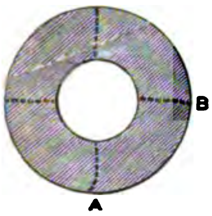
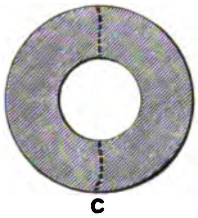


FIG. 3.



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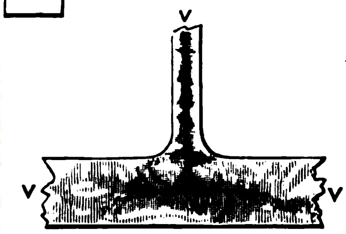

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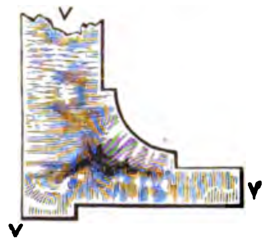

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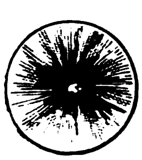

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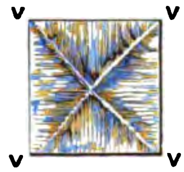

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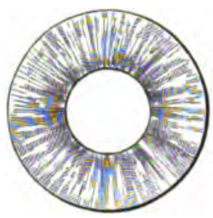


FIG. 9. B

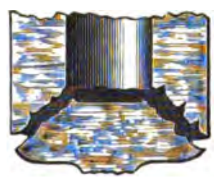


FIG. 10.

FIG. 11.

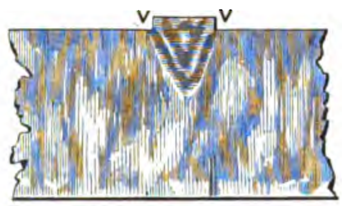


FIG. 9.

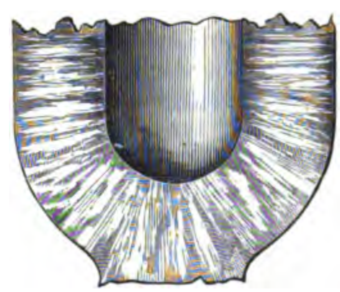


FIG. 12.

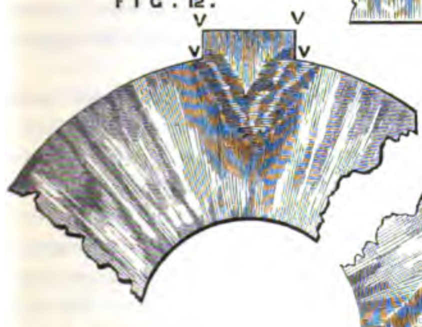


FIG. 13.

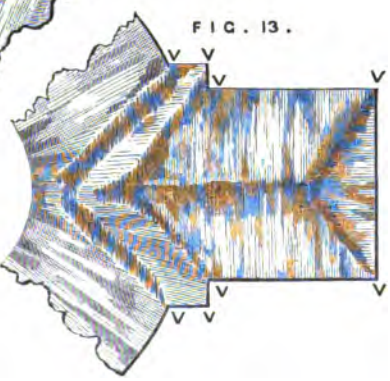


FIG. 14.

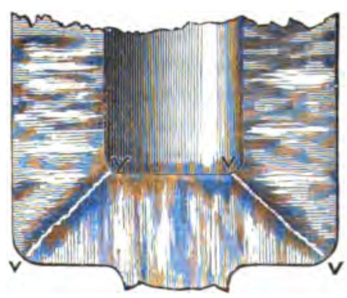


Fig. 1, Showing lines of Fracture in Cast Iron Ordnance subjected to Explosive Strains; Figs. 2, 3, Illustrating the fact that Rupture takes place first in the Interior of the Gun, the Fragments folding over on the Points A, B, C; Figs. 4, 5, Showing the Spongy character of Cast Iron in Cruciform Castings; Figs. 6, 7, 8, 10, Showing lines of Crystallisation, illustrating the Law of "Least Resistance;" Figs. 14, 9 B, Showing weakness of Square Breech, Fig. 14, representing Portion of the Lower or Closed End of Cylinder of the Hydraulic Press as first made for Raising the tubes of the Britannia Bridge, and which broke in the attempt, the end of the Cylinder having broken out as in Fig. 9 B; Fig. 9 representing section of part of the new Cylinder substituted for the faulty one, Fig. 14; Fig. 11, Showing section of Reinforce Ring in Plane of the Axis; Figs. 12, 13, Sections of portions of Large Cast-iron Guns, showing the weakness of Cast-Iron Trunnions. V, V, Indicate Directions of Weakness.

industry of big gun making. Just as a description of a woollen manufactory would not be complete unless some account were given of how the rough fleece, in which the fibres of the wool are lying in every direction, is carded and arranged so as to give the greatest amount of strength after it has been spun into threads, so in an account of the making of big guns an explanation is necessary of the means employed to arrange the fibres of the iron, and these are, as already stated, heat and pressure.

We will now go on to see how cast iron, in the light of Mr. Mallet's discoveries, is an unsuitable material for artillery. First of all, its greatest strength is against a compressive strain, and it is therefore not suited for resisting the tensile strains that occur when a charge of gunpowder is exploded in the chamber of a gun. Secondly, the process of casting is not only liable to a great many crystalline changes, which depend upon the shape of the casting and the manner in which the heat leaves it (Figs. 6, 7, 8, 10), but it is incapable of being subjected to the pressure in certain directions, which has already been compared to the carding process in a woollen mill, and which is essential to obtaining the greatest strength in the direction of a tensile strain. The first person who has turned to practical account the important influence of pressure upon the strength of molten metal is Sir Joseph Whitworth, whose "fluid compressed steel" is the strongest material known, but being in itself of a malleable character, and so afterwards capable of being subjected to pressure, it cannot be looked upon as affording any hope that cast iron can be similarly improved in its subsequent treatment after the process of casting. The inventor of this process has proved, however, that the new material of "fluid compressed steel" is thoroughly suited to the construction of artillery. The principles of the process are exactly those which are laid down by Mr. Mallet as essential to the construction of reliable guns; and at some no distant date Sir Joseph Whitworth's process may assume the position of a great industry; meantime we will confine ourselves to the making of guns as practised at Woolwich, based as it is on the labours of Mr. Mallet, and because it may be said to be the only scientific process conducted upon a large scale in this or any other country.

Such work as that which we have attempted to explain, although unrecognised by those persons whose position ought to enable them to accord an ungrudging acknowledgment to those to whom honour is due, could not long remain unappropriated in such a practical age as the one in which we live. Accordingly, we find that the principles laid down by Mr. Mallet were not long in abeyance, but soon were interpreted by an engineer who proved himself to be one of the ablest masters of the art of applying practical means to a scientific end that has ever bestowed his services on this country. We refer to Mr. Fraser, of Woolwich Arsenal. Of the difficulties which lay in his way against having his plans carried out, the obstructions of nature formed a comparatively small proportion. Fortunately, however, for Mr. Fraser and for the country, an officer was at the head of the executive at Woolwich for a length of time that sufficed for his intelligent appreciation of Mr. Fraser's views to be put upon its trial. The result has been the development of an industry at Woolwich which is distinguished not only for its consistency with scientific principles, but which is carried out in all its details in a manner that stands unrivalled by the efforts of private enterprise. In the next chapter we hope to give a description of the many ingenious devices which have been adopted in order to attain this result; but in order to understand to some extent the revolution that has been accomplished, it is necessary to consider the state of the industry even so recently as the time of the Crimean war. At that time Woolwich Arsenal presented the appearance of a factory, the extent of which was rivalled by hundreds of private establishments through the length and breadth of the country; now it has assumed the appearance of a town.*

No doubt this advance has been rendered possible only by the improvements which have been made in the appliances necessary to the manipulation of iron upon a great scale; but in the department of big guns at Woolwich it has been above all things necessary to appreciate the nature and capabilities of these improvements, which of itself requires intelligence of the highest order. There is no one at all familiar with the great factory who is not aware of the almost instinctive readiness on the part of Mr. Fraser and his assistants to adopt and assimilate anything and everything that is good in the world of invention; and so it has come to be the case that the department of big guns at Woolwich may in all respects be looked upon as a model establishment, both with regard to efficiency and economy. Every

* See Mr. Robert Smiles's very interesting description of the Woolwich Arsenal in Vol. II. of this work, pp. 286—294.

process is conducted with an amount of precision that to the onlooker appears to give it an outward appearance of easiness, although he well knows that the acquisition of that ease is simply the perfection of mechanical and manipulative skill. Huge masses of white hot iron, which it would take a team of a hundred horses to drag along the ground, are removed from place to place with a care that might appear to be better bestowed upon the labours of the statuary, but which is essential to the crystalline stability, and to the ultimate strength of the whole structure. Every blow of the steam hammer, although applied with apparent indifference, has been studied in relation to the effects of its pressure upon the mass; and at certain stages of the work they are regarded as necessary evils, for which a substitute would at once be employed if the result of welding could be attained by other means.

Comparing the past with the present, it is by going back to the period of the Crimean war, which is still a vivid memory among the middle-aged persons of our own day, that we find the rapid progress that has been made. At that time the labours of the forge had been almost entirely abandoned in the construction of artillery, and the art which produced Mons Meg and the other great guns referred to in the previous chapter had become well-nigh extinct. No trustworthy system had been substituted. Rule of thumb, in the choice of metal and in the manner of casting it, was the only safeguard against disastrous explosions, and when it failed —as too often happened—science, when appealed to, was found unable to give satisfactory replies. The phenomenon of the drooping muzzle and many other effects of repeated firing, which are now explained by the effects of heat upon the material of the gun, were accounted for by reasoning upon data that have been proved to be fallacious.

Upon referring to Figs. 4 and 5, some idea may be formed of the defects of a system which the scientific investigations referred to in this chapter have rendered obsolete. These show sections of cast iron of a cruciform contour, in which the reader will notice the loose crystalline structure towards the centre of the castings. This is an inherent condition in all castings that have been "poured" in in the ordinary way, and under the old system of casting guns this species of defect occurred at the breech, a part that is subjected to the greatest strain. Referring to Figs. 14 and 9 B, it will be seen that where the form was square the crystalline weakness extended all round the back of the breech, and rendered it liable to be blown out in one piece. Under ordinary circumstances the spongy character of the breech was a constant source of trouble, but instead of its being put down to its proper cause, it was almost universally attributed to a chemical action which the gases of the exploded gunpowder exercise upon the metal. Again turning to Fig. 1 (we are indebted to Mr. Mallet's exhaustive work upon the construction of artillery for our illustrations), which shows the lines of fracture in a burst cast-iron cannon, we find an example of what must, from the very fact of the fractures being where they are, be lines of least strength or greatest weakness. The invariable manner in which these fractures followed certain lines remained for a long time inexplicable, but in the light of the explanations we have attempted to give, they are easily interpreted. The planes of crystallisation under ordinary conditions of casting group themselves perpendicularly to the surfaces of external contour, and this law enables us not only to account for the appearance of the fractures as shown in Fig. 1, but also to predict the lines of greatest weakness in the mass before it has been subjected to an excessive or dangerous strain. The gun, rupturing first in the interior, bursts asunder, and in doing so folds over, as in Fig. 3, at the bottom of the dotted line, which forms a sort of hinge; or, as in Fig. 2, at the bottom and right-hand side. Not only, then, is cast iron unsuited for the purposes of artillery, from its chemical and molecular nature, but from the uncertainty which must always attend its crystalline structure during the process of cooling. These objections were of themselves sufficient to lead to the abandonment of cast metal of all sorts, whether iron or bronze; but it is almost unnecessary to add that the adoption of malleable iron as a substitute would have been attended with few, if any advantages, if its use had not been regulated so as to take advantage of the greatest strength of which it is capable. It has been attempted in the present chapter to explain the principles of crystalline adaptability, upon which the superiority of wrought iron chiefly depends; in the next we will describe how these principles are carried into practice at Woolwich.

HEMP, FLAX, AND JUTE.—XXII.

INTRODUCTION OF JUTE—THE PLANT AND ITS CULTIVATION—A BENGAL INDUSTRY.

By David Bremner, Author of "The Industries of Scotland."

ABOUT a century ago the East India Company imported small quantities of jute into England, and also sent some to various parts of the Continent and America, with the object of its being utilised in the textile manufactures. The fibre, however, found little favour with anybody, and it was not applied to higher purposes than the making of door-mats and clothes-lines. In course of time samples of the new fibre fell into the hands of some manufacturers at Abingdon, Oxfordshire, and after sundry experiments they concluded that the best purpose to which it could be put was to form it into carpets. It was not, however, until the manufacturers of Dundee gave jute a full trial that its value was recognised, and an important addition made to the textile industries of the country. In the year 1822 several small parcels of jute were sent to flax-spinners in Dundee by friends in London, with the object of having it tested on the flax machinery. The fibres were found to be hard, dry, and refractory, and no satisfactory yarn could at first be made of it, either by hand or machine spinning. Mr. William Anderson persevered, however, and after a time succeeded in producing from the finer fibres a weft suitable for low-priced padding canvas, and from the coarser a weft for nail bagging and other heavy fabrics. In addition to the difficulties presented by the fibre itself, its use was retarded by a prevailing impression that it would not stand water, and that it was so weak as to be unworthy of being spun or woven. This prejudice arose from the fact that "sunn hemp," another East Indian fibre, rotted when wet, and was not at all justified by experience.

For a time it seemed as if the fibre was doomed to rejection, and to occupy no higher rank in the roll of industrial materials than that of being suitable for making "gunny bags." Its day for recognition came at last, however: in what manner Mr. Warden, its historian, relates with considerable detail, and from his record we shall take a few facts. Mr. Thomas Neish, merchant, Dundee, was so far satisfied with the results of Mr. Anderson's experiments that he procured some of the fibre, and tried to induce his friends in the flax-spinning business to try it on their machinery. In this he failed, however, until about the year 1832, when the firm of Balfour and Meldrum yielded to his persuasions, and persevered with their experiments until they achieved a gratifying measure of success. Mr. James Watt, another merchant, also took up the case of jute, and under his superintendence an old breaker-card was adapted to deal with the fibre, with results which induced Mr. Watt to embark in the trade of jute spinner and manufacturer. The samples of jute brought to Dundee in 1822 were sold for £11 per ton; ten years later the price was from £14 15s. to £18. Great perseverance was displayed by the firms who had made a beginning with the new fibre. Some specimens of jute yarns and carpeting made at Abingdon were sent to Dundee about the beginning of the year 1834, and as these proved that a cheap and presentable floor covering could be made of jute, several manufacturers turned their attention to that branch of trade. "Jute is one of the most easily dyed fibres known, and the colours it takes on are bright and beautiful. The common dyes are quickly applied, but they are very fugitive, and when exposed to the sun's rays soon become faint and dull. By the common process the colouring matter strikes little more than the outside of the fibre, and, as it were, paints it; and this mode of dyeing requires little material and is done at small cost. The fibres of jute do not subdivide so minutely as flax, and they are of a hard, dry nature, and to a considerable extent impervious to moisture. It therefore requires a more complex process to make the colouring materials thoroughly penetrate the fibre so as to make the dye lasting. This can, however, be accomplished, and the better class of goods made of dyed jute undergo this process, which makes the colours both bright and faster." Beautiful specimens of carpet are produced in jute, and the brightness of the colouring captivates the eye, compensating, along with the low price at which the material is sold, for its defective durability when contrasted with a woollen fabric.

Notwithstanding the appreciation which the jute fibre met with at the hands of some manufacturers, who looked upon it as having "a future," there were considerable misgivings in other minds as to the advisability of allowing it to enter into competition with flax; and these found expression from time to time in the public prints. On the 6th of February, 1836, the *Dundee Advertiser*, in discussing

the fluctuations in the linen trade during the previous year or two, said :—" In consequence of the great rise in flax from the failure of the flax crop, substitutes had begun to be used. But the mischief is, that were linens to advance as much as flax had done cotton would come into competition, and thus the manufacturer was precluded, unless at a great sacrifice, from pursuing his trade honestly, and obliged to use substitutes. Of these the most common was jute hemp, an Eastern production, which, from being a drug in the London and Liverpool markets, was then worth about £17 a ton, an advance within a few months of from forty to fifty per cent. This article is weak, of a reddish-brown colour, very soft and silky, but totally destitute of moisture. The use of this and other substitutes would tend to lower the character of our manufactures very much, though it is to be hoped the necessity for using them will not continue long enough to ruin it altogether."

THE JUTE PLANT.
(1) Wild Specimen of *Corchorus olitorius*; (2) Upper part of the same, in flower (one-third nat. size; flowers yellow); (3) Single Flower (nat. size); (4) Ripe Fruit (nat. size).

As the modes of working the jute fibre were improved the article grew in favour, and soon after the above passage was written became fairly established with an influential body of the local manufacturers. In 1836 the price of jute had risen to from £22 to £23 per ton, and two years later a great impetus was given to the use of the fibre by the Dutch Government resolving to use it for the manufacture of the coffee bags required in connection with their West Indian colonies. In producing yarn for this purpose the Dundee spinners did a lucrative business, and one use of the fibre led to another, until an important trade was developed. The manner in which the difficulties experienced in the way of spinning jute were removed is thus recorded by Mr. Warden :—" The long strikes of jute intended for linen yarn were cut of a proper length for hackling, and the teaser was erected to tear down and make into tow what was designed to be spun. The cards were altered to suit the new fibre, and the preparing and spinning machinery strengthened and enlarged, the better to turn it into yarn. The application of oil softened the material, made it more pliable, and gave it better spinning properties. These were still more improved by spreading out the strikes, saturating them thoroughly with oil and water, and allowing the jute to remain in the 'batch' for several days before being spun. This operation was first performed in a thorough manner by William Taylor, at Ruthven Mill, and it has added greatly to the spinning qualities of the material, improved the appearance of the yarn, and materially lessened the waste and consequent cost of spinning. After the preparing and spinning machinery was properly adapted for jute, and after the appliances of oil and water had been judiciously laid on, the difficulties in the way of spinning the fibre were removed. The bad odour which it had at first was then forgotten, and profitable returns made it smell fragrantly to the spinner."

The effect produced on the flax trade of Dundee by the introduction of jute was set forth in a paper read before the Social Science Congress at Edinburgh in 1863, by the secretary of the Dundee Chamber of Commerce, from which we extract the following passage :—" By the introduction of jute into the linen trade great changes have been brought about. In place of sackcloth, bagging, and other coarse fabrics being made from hemp, hemp codilla, flax codilla, and coarse tows, they are all now entirely made from jute, and some of these raw materials are not now known in the trade. Though much the same quantity of flax and tow is now imported as many years ago, the real linen trade is in this way supplemented, the quantity formerly required in the coarser branches being now available for other purposes. On the first introduction of jute it was only used for fabrics of the coarsest description : in fact, it was

then considered that it never could be used otherwise; but from the improvements in machinery, and from gradually increasing experience, this has been found to be erroneous. The more common descriptions of Osnaburgs, sheetings, and many other fabrics are now manufactured solely from it; or these goods, in place of being made of flax or tow, as formerly, are now composed partly of tow and partly of jute. Fine goods are also manufactured from a combination of jute and cotton. In this manner has the linen trade again been most largely supplemented. The jute trade has increased so rapidly, and the goods made from the fibre are now so highly appreciated over the whole world, that, looking to the future, one is entitled to say that in extent it will probably only be rivalled by the cotton manufacture. The pack-sheet, baggings, sackings, sacks, and woolpacks of Dundee are used in almost every quarter of the globe. When I state that they are by far the cheapest manufactures of this description that can be made from any raw material, it will be no matter of surprise that this trade still continues to advance with great strides. There is still one fabric worthy of particular notice which owes its existence solely to jute: it is the manufacture of jute carpets. These have nearly the appearance of carpets made from wool; and though they are neither so durable nor retain their colour so well, still, when I state that the cost varies from 6d. to 1s. 4d. a yard, it is not remarkable that they should be greatly used. Rugs, in imitation of wool, are also manufactured from the same material. The reporters appointed by the jury on jute goods at the International Exhibition last year said:—'It is in Scotland exclusively where goods made from jute represent a large branch of industry. This very cheap raw material is employed there—either pure or mixed—to make ordinary brown cloth, but more especially sacking, packing-cloth, and carpets. The jute yarns used for carpets are of the richest and most varied colours, and are sometimes used with cocoa fibre. Even the Brussels or velvet carpet is imitated with success in appearance, if not in durability.'"

According to a return made to Parliament in 1875, there were then in the United Kingdom 110 jute factories, containing 1,062 carding machines, 60 combing machines, 220,911 spinning spindles, 9,274 doubling spindles, and 9,599 power-looms, and giving employment to 37,920 persons. Of these factories, 15 were in England and Wales, 84 in Scotland, and 11 in Ireland.

Before proceeding further with our account of the manufacture of jute it is desirable that we should describe the plant from which it is derived and the mode of its cultivation. Jute is the fibre of plants of the *Corchorus* family, two species of which yield the chief supply: namely, *Corchorus olitorius* and *Corchorus capsularis*. These are common in most parts of India, and are thus described in botanical phraseology:—*Corchorus olitorius*, pot-herb or Jew's-mallow, is an herbaceous annual, which grows to a height of from five to ten, or, under favourable circumstances, twelve or fourteen feet. The stem is erect, smooth, cylindrical, and more or less branched towards the top. The leaves are smooth and of a lively green colour, alternate on foot-stalks, oval or ovo-lanceolate in shape, with the margin dentate, and with the two lower dentilures terminated by a slender filament. The stipules are simple, awl-shaped, and of reddish colour at the base; and the peduncles or flower-stocks are one or two-flowered. The flowers are small, having the calyx consisting of five pieces or sepals, the corolla of five yellow petals, and the stamens numerous. Torus or nectary cup-shaped, with glands at the base of the petals. Ovary solitary, ripening into a long, nearly cylindrical capsule, ten-ribbed, six to eight times longer than it is broad, five-celled, and formed of five valves, with five terminal points. Seed numerous, with nearly perfect transverse partitions between them. *Corchorus capsularis* differs little from this. Its flowers are smaller, its seeds fewer, and the seed-vessels are short and wrinkled. The first-named variety of the plant is cultivated at Aleppo as a pot-herb, and is said to have been used in that way from time immemorial by the people of Egypt and Arabia. In India the leaves of both varieties are eaten. Europeans who have partaken of the dish describe it as being coarse and unsavoury, and not likely to find its way to Western tables.

In order to secure a good crop the cultivator has to keep several things in view. He must select land which stands high and is not subject to inundation. This he must drain and manure well, and on putting the seed into the ground in April or May, he must select a time when the soil is in a moderately moist condition. He must not sow too thickly, because if he does so, though he will secure a finer fibre than otherwise, the yield will be small, as the plants do not grow to any size when too close. On the other hand, he must not sow too sparsely, else every plant will become a tree virtually, and yield only the coarsest fibre. When properly managed, and favoured by abundant

heat and a moderate rainfall, the crop is the most profitable to which the native agriculturist can devote attention. A system of forcing is practised in some parts, which increases the yield to the grower, but deteriorates the value of the fibre to the spinner, by hardening the lower end of the stalk and also discolouring it. When ripe—which is usually about a hundred days after sowing—the plants are cut close to the roots, and the tips and upper branches are snipped off. They are then made up into bundles of from fifty to a hundred each. In order to extract the fibre, a "rotting" process, similar to that followed in the case of flax, is resorted to. It is sometimes done in a rough-and-ready way, however, the bundles being thrown into the nearest ditch, covered with turf, and there allowed to lie for eight or ten days. The proper time for removing them is determined by scraping the bark with the finger-nails, and seeing to what extent decomposition has operated. On being removed from the water, the bundles are untied and the bark removed. The latter operation is performed by the workman taking up as many stalks as he can conveniently grasp in his hand. He first removes a portion of the bark at the root end, so as to get a firm hold of the fibre, and then by striking the stalks gently against a sloping board he loosens the fibre from end to end of each stalk, and pulls it off entire. After a certain quantity of the fibre has been put through this process, the operative proceeds to wash it thoroughly. This he does by taking up a large handful, wading into the river till the water is as high as his hips, and then rinsing the jute by drawing it through and dashing it upon the water. In this way fragments of bark, glutinous matter, and other impurities are removed. The jute is next hung up to dry in the sun, and is then, after assortment, ready to be packed for the market. If the plants be too much steeped, or the fibre after extraction be allowed to lie about damp for any length of time, the quality is deteriorated. Before packing, it is usual to cut off a portion of the root end of the fibre, as it is of inferior quality. The part removed is not lost, however, as it finds purchasers among the makers of the coarser kinds of sacking; and, strange as it may appear, experiment has shown that by treatment with sulphuric acid and fermentation the jute-ends may be made to yield a spirit which bears much resemblance to whisky made from grain.

The importance of the plant to the people of Bengal and the amount of occupation it affords are stated in the following passage from Mr. Warden's "Linen Trade, Ancient and Modern:"—"A very large proportion of the jute grown in Bengal is made into cloth in the districts where it is cultivated, and this industry forms the grand domestic manufacture of all the populous eastern districts of Lower Bengal. It pervades all classes and penetrates into every household—almost every one, man, woman, and child, being in some way engaged in it. Boatmen, husbandmen, palankeen carriers, domestic servants, every one, in fact, being Hindoos—for Mussulmans spin cotton only—pass their leisure moments, distaff in hand, spinning gunny twist. It is spun by the takur and dhara: the former being a kind of spindle which is turned upon the thigh or the soles of the feet, and the latter a reel, on which the thread when sufficiently twisted is wound up. Another kind of spinning machine, called a ghurghurea, is occasionally used. A bunch of the raw material is hung up in every farmer's house or on the protruding stick of a thatched roof, and every one who has leisure forms with these spindles some coarse pack-thread, of which ropes are twisted for the use of the farm. The lower Hindoo castes from this pack-thread spin a fine thread for being made into cloth; and, there being a loom in nearly every house, very much of it is woven by the women of the lower class of people. It is especially the employment of the Hindoo widow, as it enables her to earn her bread without being a burden on her family. The cloth thus made is of various qualities, such as clothing for the family, especially the women—a great proportion of whom on all the eastern frontier wear almost nothing else—coarse fabrics, bedding, rice and sugar bags, sacking, pack-sheets, &c. Much of it is woven into short lengths and very narrow widths, two or three of which are sometimes sewn into one piece before they are sold. That intended for rice and sugar bags is made about six feet long, and from twenty-four to twenty-seven inches wide, and doubled. A considerable quantity of jute yarn is dyed and woven into cloth for various local purposes, and some of it is also sent out of the district."

SHIP BUILDING.—XXIII.

EARLY HISTORY OF STEAM NAVIGATION.

TWO means of propelling ships have been used from time immemorial, sometimes independently of each other, but often in association. Oars worked by manual power were chiefly depended upon in vessels designed for inland or coast navigation; and until comparatively modern times war-vessels were fitted to be rowed as well as sailed. Ships designed for over-sea traffic and for mercantile purposes usually depended chiefly upon their sails for propulsion, and carried much smaller crews than the vessels built for rowing. All accounts of ancient shipping give prominence to the row-galleys, manned in some cases by several hundred rowers, and capable of proceeding at a high rate of speed over considerable distances. It has been well said that "the row-galley constituted the steamships of the ancients as distinguished from their sailing vessels;" but there is the great difference that in modern times the progress of invention has swept away the cruelties and wretchedness which will always remain associated with the name of "galley-slave," and established in their place the giant power of the steam-engine.

Many treatises have been composed, and hot debates have arisen, respecting the arrangements of the ancient galleys, especially those of large size. To the antiquarian such discussions may still be interesting, and he may find it a pleasant pastime to attempt a reconstruction of the "triremes," or "quinqueremes," or "septiremes," which once formed the pride of Mediterranean war-fleets. He may gravely discuss the probability, or otherwise, of the correctness of the accounts which have come down to us of the great ship of Ptolemy Philopator, which is said to have been two hundred and eighty cubits long, to have required four thousand rowers, and to have been manned by more than three thousand mariners. Our concern, however, is rather with present practice than with so remote a past; and we allude to it only to show the contrast between what has been, and what is, in ship-propulsion. Many centuries before the Christian era we know that propulsion both by oars and by sails was well understood; and similar methods remained in use, without any successful attempt at improvement, until the close of the eighteenth century. There had, it is true, been indications of a desire for improvement in the seventeenth century, when the application of steam-power began to attra[illegible] Denis Papin and Savery are said t[illegible]ven small boats by steam-powe[illegible]wheels, about the end of th[illegible]an Hulls in 1736 patent[illegible] steamer, which strikingly [illegible] features vessels still in use. [illegible] posed more or less feasible scheme[illegible] the imperfect forms of the steam-en[illegible] known to the work of propelling or towing [illegible] The French Academy of Sciences, which did [illegible] much to encourage naval architecture during the latter half of the eighteenth century, did not fail to notice these occurrences; but offered valuable prizes for proposals to improve existing systems of propulsion. Among the competitors were men of the eminence of Bernoulli, Bouguer, and Euler, but their plans were almost wholly based on the supposition that manual power should be applied, and no practical advantage resulted from the competition. To private enterprise, unaided by the stimulus of competition under such auspices, the world owes the introduction and extension of steam navigation. And it is no less remarkable that almost simultaneously, and probably with little knowledge of what was being done elsewhere, the pioneers of progress set to work in England, France, and the United States. It is, however, a matter for congratulation that in the various claims which have been advanced for the credit of priority of invention, no one is found to dispute the influence which James Watt's improvements in the steam-engine had upon its application to marine propulsion. Professor Rankine has justly remarked that "the early attempts at steam navigation . . . . appear to have failed chiefly because of the imperfect nature of the means employed for the transmission of motion from the piston to the propeller: Watt's invention of the rotative engine, which effects that transmission smoothly and without shocks, was an indispensable step towards the success of steam navigation."

The real beginnings of practical steam navigation are to be found in the period 1780—90. In Great Britain the two workers whose names should always be held in honour, are, Mr. Miller of Dalswinton, and Mr. Symington, whose joint labours resulted in the production of a successful paddle-wheel steamer which attained a speed of

five miles an hour on trial in November, 1788. Mr. Miller had previously been experimenting with boats driven by paddle-wheels worked by manual power: a plan resembling that proposed thirty or forty years before by competitors for the prizes of the Academy of Sciences, and not very dissimilar from plans adopted centuries before by the Carthaginians and Romans in their galleys. Symington was a working engineer, of considerable ability, whose ingenuity had been displayed in the contrivance of a locomotive engine for use on common roads; and it was an engine of this character, of about one horse-power, which took the place of manual power in the first experimental steamer. About a year later (December, 1789) another set of experiments was made upon the Forth and Clyde Canal with a vessel sixty feet long, driven by engines of twelve horse-power. A speed of about seven miles per hour was attained, and the experiment was thoroughly successful; although its practical importance was not realised at the time. Mr. Miller spent a large fortune without reaping the benefits which his enterprise so richly deserved. Symington also long sought in vain for another patron whose belief in the future of steam navigation was sufficient to secure the necessary funds for the construction of a third steamer. It was not until twelve years had elapsed that Symington found his opportunity; Lord Dundas then employing him to equip a steamer for use on the Forth and Clyde Canal. The *Charlotte Dundas* was completed and tried early in 1802; her success was unquestioned, but she was not used on the canal, possibly because it was feared that the wash of water from the paddle would damage the banks. So ended the second attempt made in Great Britain to introduce steamers; and ten years more elapsed before a third attempt was made. Poor Symington lived long enough to see others succeeding in the path which he had first indicated: but he died in poverty—a sad fate for the man who constructed "the first practical steam-boat." Mr. Woodcroft, in his standard work on the subject, remarks that "Symington had the undoubted merit of having combined, for the first time, those improvements

William Symington.

which constitute the present system of steam navigation;" and it is a matter of surprise that so long a time elapsed before the experience obtained in the *Charlotte Dundas*, and her two predecessors, led to the further use of the steam-engine on board ships.

There are somewhat doubtful records of steam-boats having been constructed in France by the Marquis de Jouffroy about the year 1781; but the first well-authenticated trials of a steam-vessel in France are those made on the Seine by Fulton, the American, in 1803. His countrymen claim for Fulton the honour of being the chief promoter of steam navigation, and it may be readily conceded that he did most valuable work. It must not be forgotten, however, that Symington preceded him in this country, and that in America many other trials were made before Fulton built his first steamer. There is evidence to show that Fulton made a careful study of the machinery of the *Charlotte Dundas* before building the boat tried on the Seine. It must also be noted that the engine for that boat, as well as that for the *Clermont*, the first steamer he built in the United States (in 1806) were made in England. Still, Fulton deserves great credit for giving a fresh start to steam navigation when its progress in Great Britain was suspended. The *Clermont* has been well described as the "first steam-boat in the world regularly and continuously engaged in passenger traffic." Notwithstanding very serious opposition, Fulton achieved such a success that his example was soon imitated on other rivers of the New World, and steamers of greater speed, as well as improved types, were multiplied rapidly during a period when steam navigation was making comparatively slow progress in Europe.

Amongst the earlier inventors of steam-propelled vessels in America, Fitch and Rumsey cannot be passed over unnoticed. Rumsey began his work in 1784, but was not very successful; his plan consisted in using a steam engine to eject water from the stern of a vessel—what would now be termed a "water-jet" propeller. Fitch built a small steam-boat as early as 1786, and a second in the following year; while he attempted to establish a passenger steamer on the Delaware in 1790. The most notable features in his steamers were the propellers. Instead of using paddle-wheels, as had been done by most inventors, Fitch devised a plan by which a number of oars or sculls placed at the stern of the vessel could be driven by steam-power. Another American deserving mention is Stevens, who in 1804–5 made a series of trials on two boats driven by screw-propellers; although a certain amount of success attended the trials, they led to no practical result, and the paddle-wheel was used for nearly thirty years longer.

In 1811, four years after the construction of the *Clermont* by Fulton, another attempt was made in this country to establish steam navigation. Mr. Henry Bell had for many years endeavoured to enforce his views on the Admiralty, as well as on various foreign governments, but had failed. He finally decided to build a vessel at his own risk and cost. She was constructed by Messrs. Wood, of Port Glasgow, was about forty feet long on the keel, ten and a half feet beam, and had paddle-wheel propellers driven by a very peculiar kind of engine, which has since been exhibited at South Kensington. At first she was employed on the Clyde, between Glasgow and Greenock; and afterwards on the Firth of Forth. She began work in August, 1812; and in the following year a rival steamer, named the *Elizabeth*, commenced running on the Clyde. The same year witnessed the building of several other steamers, for river service; Leeds, Manchester, and Bristol contributing to the work. The first steamer which appeared on the Thames is said to have come through the canals from Bath about 1814, but "she was prevented by the watermen's company from taking passengers," and returned to Bath. In the following year a more successful attempt was made to introduce steamers on the Thames; and opposition gradually died out as experience showed the advantages of the new plan of propulsion.

The Clyde had taken the lead in the construction of steamships, and consequently many vessels built there had to make coasting voyages in order to reach their regular stations on other rivers. In 1815 a paddle steamer which was too large to pass through the Forth and Clyde Canal, made a passage from the Clyde to Dublin, and thence to London. Steamers also began to ply between London and Margate in 1815–6; and in 1817 Mr. James Watt crossed the Channel to the Scheldt in a vessel named the *Caledonia*, afterwards ascending the Rhine to Coblentz. The *Caledonia* was thus the pioneer of the great steam flotilla now employed on that noble river. By these coasting voyages and short sea-passages confidence was gradually established in the sea-going capabilities of steamers; and in 1818 Mr. David Napier started the *Rob Roy* on the service between Glasgow and Belfast. The *Rob Roy* was "the first regular sea-

going steamer which had been built," but she did not long remain alone. Her success led to the employment of steam mail-packets between Holyhead and Dublin, as well as between Southampton and Havre; the *Rob Roy* herself was eventually placed on the line between Dover and Calais. The coasting trade also began to pass into the possession of steamships; in 1822 the line from Glasgow to Liverpool was established, that from Leith to London having been established soon after. The first *iron* steamer, the *Aaron Manby*, was constructed in 1821, and crossed the Channel to take up her station on the Seine.*

The earliest ocean voyages performed by steamers were made as passages from the ports where they had been constructed to the stations upon which they were to be employed. In 1819 the *Savannah* crossed the Atlantic from the port of that name, in the State of Georgia, to Liverpool, on her way to St. Petersburg, taking thirty-one days on the passage, and partly sailing as well as steaming. This little vessel was 100 feet long, twenty-six feet broad, and about 300 tons burden; her steaming capabilities were so moderate that the passage could not have been made independently of sail-power. After proceeding to Russia, she returned to America, crossing from Norway to New York in twenty-five days. A still more daring venture was made about six years later, when the steam-yacht *Falcon*, of about 175 tons, proceeded from England to India: her steam power was small, and she usually went under sail. She was purchased by the Indian Government, and converted into a sailing-vessel: but the example thus set was soon followed. In 1825 the *Enterprise*, of 470 tons burden, and 120 horse-power, made a passage from England to Calcutta in 113 days, carrying seventeen passengers. She too was purchased by the Indian Government, and did good service as a mail-steamer during the Burmese war, and for many years after, exemplifying the advantages of steam navigation so powerfully as to lead to its comparatively rapid extension on the coasts and rivers of India. Her success also gave weight to the arguments of those far-seeing persons who, even at that early period, advocated the extensive employment of steam-vessels on the service between England and India. There were two proposals for effecting this object; one, for steamers to proceed the whole distance *viâ* the Cape of Good Hope, as the *Enterprise* had done; the second, for the so-called "overland route" across the Isthmus of Suez, with steamers running from Bombay to Suez, and from Alexandria to England, touching at Malta and Gibraltar. The latter plan was adopted; and with certain modifications it remained in force from 1835 until the Suez Canal was opened, in 1869.

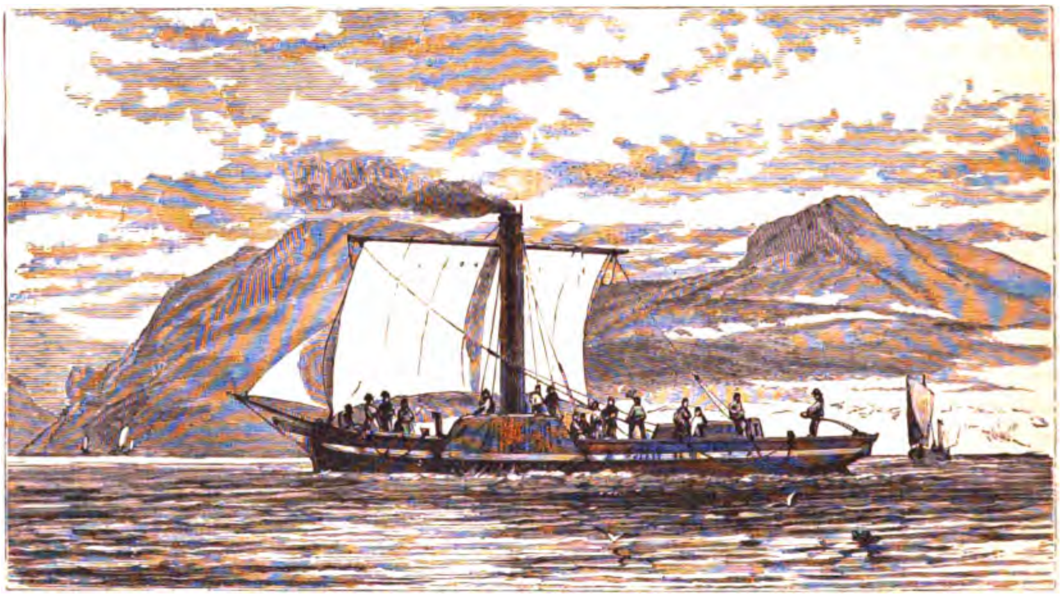
* A description of this vessel will be found at p. 143, Vol. I.

Another notable attempt to employ steamers in ocean navigation was made by the Dutch about 1828–9. Having purchased an English-built steamer named the *Curaçoa*, of about 350 tons burden and 100 horse-power, the owners placed her on the line between Holland and the Dutch West Indies. Like the other sea-going steamers of that period, she was fully rigged, and performed a large part of her passages under sail alone. She is said to have succeeded commercially, and gave good evidence of the capabilities of steamers to withstand the heaviest weather and stormiest seas: but the experience thus gained was slow in its influence on the progress of ocean steam navigation, and eight or nine years elapsed before a successful attempt was made to establish a Transatlantic service of steamers. Before that consummation was reached, another and much larger steamer, named the *Royal William*, built in Canada but fitted with engines of English construction, made the passage (in 1832) from Quebec to Gravesend in twenty-three days, including three days' detention at Nova Scotia. This vessel, however, was not built for the Transatlantic trade, and was purchased by the Portuguese Government.

By this time the use of steam-packets had become general in European waters, and the first steamers constructed for the Royal Navy were used either in the packet-service or as tugs. The first steamer built by order of the Admiralty was the *Comet*, of 238 tons burden and 80 horse-power; she was laid down in 1819. Nearly at the same time another paddle-steamer, the *Monkey*, was purchased by the Admiralty, having been built at Rotherhithe by Mr. Evans; after nearly seventy years' service, the *Monkey* still continues in use at Chatham. After 1823, the building of paddle-wheel steamers for the Navy progressed rapidly, and in successive vessels larger dimensions, with more powerful engines, were adopted, in association with armaments which were by no means contemptible in those days; and thus was the foundation laid for our present magnificent fleet of steam-propelled war-ships. Up to 1840, the largest paddle-wheel sloops constructed did not exceed 1,200 tons burden and 350 horse-power.

The Admiralty steam-packets did good service formerly, although their work has since passed into the hands of merchant shipowners. As an

example, take the important service to the Mediterranean, which was performed by sailing-vessels until 1830—less than half a century ago. These sailing-packets occupied, on an average, about three months in the passage from Falmouth to Corfu; and their performances, of course, varied greatly with differences in wind and weather. The first steam-packet, named the *Meteor*, sailed in February, 1830, and made the passage to Corfu and back in forty-seven days. Mr. Fincham, who records these particulars, adds the following interesting passage:—"The packet that left England in the following month was conveyed by a sailing-vessel . . . which left Falmouth on the 6th of March, and reached Corfu on the 13th of June. But the *Echo* steam-vessel, which left England on the 6th of April, had reached her destination and returned; and even the *Meteor*, which conveyed the mail from England in May, delivered her charge (at Corfu), and was again in England in nine days after the sailing-vessel reached Corfu."



THE "COMET."

Successes such as these, and the experience gained in the few over-sea passages above recorded, could not fail to direct attention to the desirability of extending steam navigation to the Transatlantic service between Great Britain and the United States. In 1835, lively discussions took place as to the possibility of making steamers commercially remunerative on this route; and Dr. Lardner, whose scientific reputation gave weight to his opinion, declared against the scheme. On the other hand, competent shipbuilders and engineers, like Mr. Macgregor Laird and Mr. I. K. Brunel, were convinced that the plan was feasible, and they found no difficulty in obtaining funds to put the matter to a practical test. The first steam-ship designed and built expressly for this service was the *Great Western*: but the first vessel which was despatched from England was the *Sirius*, a vessel originally constructed to run between London and Cork. The *Sirius* left Cork on the 4th of April, 1838, and reached New York on the 22nd of April. The *Great Western* left Bristol on the 7th of April, and reached New York on the 23rd. On the return voyages, the *Sirius* took sixteen days, and the *Great Western* fourteen days; but their rivalry did not continue, as the *Sirius* was taken off the line, and employed in the trade with Russia. The *Great Western* remained at work on the Transatlantic service for eight or nine years, and was consequently fairly entitled to the honour of being the first steamer which succeeded in the competition with the magnificent clipper-sailing ships that previously monopolised the passenger-traffic between Great Britain and the United States. The average outward passage of these sailing ships between Liverpool and New York was estimated at thirty-six days, and the average homeward passage at twenty-four days, so that the triumph of the steamers was complete.

HEALTH AND DISEASE IN INDUSTRIAL OCCUPATIONS.—IX.

POTTERS AND LEAD WORKERS AND THEIR DISEASES.

By Andrea Rabagliati, M.A., M.D., Honorary Surgeon to the Bradford Infirmary.

As in the case of the operatives whom we have already considered, so in that of potters, the most common diseases from which they suffer are those of the lungs—bronchitis and consumption. We find from tables based on investigations among the out-patients of the North Staffordshire Infirmary that 57 per cent. of the male patients who work in potteries suffer from bronchitis and consumption, as against 31 per cent. of male patients in the same district who do not work in potteries. Among the female patients, potters showed a proportion of 24 per cent. of the same diseases, while the non-potters gave a proportion of 37. These figures require some explanation. Why, it may be asked, should a much larger proportion of male potters suffer from these affections than of male non-potters? and why, on the other hand, should the proportion be much less among female potters than among female non-potters? First of all, let it be understood that not all the cases of lung affection among potters are to be attributed to the nature of their occupation. The proportion of these diseases is greater in the North Staffordshire district than in England in general; and this is mainly due to two causes: viz., the dampness of the climate and the clay soil. A clayey soil, being retentive of moisture, induces a cold, raw, damp climate, a condition very unsuitable for affections of the lungs, which demand a sandy or gravelly soil, and a dry, warm, and equable climate. As to the susceptibility of male potters to lung disease, this is doubtless primarily due to their occupation, which involves, as Dr. Arlidge has shown, the taking into their lungs of more or less dust derived from the clay with which they work. This so-called dust is rather a siliceous compound than a true clay-dust, and its effects differ from that of clay as the physical properties of the former differ from those of the latter. In our consideration of the effects of dust as such on the lungs, we did not enter upon this point, feeling that future opportunities would arise for its discussion. It must now, however, be pointed out, that in addition to the distinction with which we are already familiar between organic and inorganic dust, further divisions must be made in both classes according to the physical properties of different sorts. Thus some sorts of dust have *rounded surfaces;* for example, the lead-dust, to which reference must be made immediately. These kinds of dust act no doubt as irritants, but not to the same extent nor in the same cutting, tearing, wounding way as particles, for instance, of iron-filings, which have sharp, spiked outlines, and when inhaled into the lungs act not only as simple mechanical irritants like lead-dust, but in addition tend to drive their sharp edges into the lung tissue with every heaving of the chest and every movement that takes place either in breathing or in work. The consequence is that much more serious injury to the breathing-organs results from this sort of dust than that, severe as it is, which is the effect of breathing in dust composed of particles with rounder margins, which if they irritate, do not tear the lungs or cut them. The same differences are to be found in the sorts of organic dust—as some kinds of fibres, for instance, are spiked, some are barbed, and some are sharp-pointed, while others are blunt and therefore incapable of wounding the tissues, although they damage or interfere with them as simple mechanical irritants. The siliceous dust, to the hurtful effects of which potters are exposed, is in turn composed of particles having not round and smooth borders, but having either sharp edges or spiked projecting points, which wound the lung tissues and not only irritate, but cut and tear them. In the various processes to which it is submitted this siliceous dust becomes more or less dried, and particles of it get diffused through the air. In order to account for the greater prevalence of lung affections among male potters than among female potters, it is pointed out by Dr. Arlidge "that male potters are much more the victims of this dust inhalation than females employed in the pottery manufacture; inasmuch as most of the processes in which dust is liable to be thrown off from the clay are carried on by men and lads. A certain proportion of women and girls are engaged in the clay departments, in turning the potter's wheel, in lathe-treading, and in cleaning and scouring the ware. And the last-named process, viz., china scouring, is particularly destructive of life by the breathing of dust and the setting up of lung disease. But the number so engaged represents but a small proportion of the females, who are for the most part occupied in the finishing departments

of the manufacture, namely, in the printing shops, in 'transferring' and in 'paper-cutting,' in printing and enamelling on the glazed ware, in gilding and burnishing the gold, and in the warehouses. Before these processes are undertaken, the clay has been converted by fire into earthenware or china, as the case may be, and consequently is no longer in a condition to evolve dust. We do not, therefore, meet with the bronchitis or potter's asthma among women, as in the case of the men engaged in pot works."

The comparative immunity from diseases of the chest found among female pottery operatives, as compared with their sisters of the same district who do not work in potteries, is attributed to the facts that women working in potteries are not exposed to the dust as the male workers are; that they are comparatively little exposed to weather and other out-door influences, and that they are protected from cold by the warmed and ventilated rooms in which they work. In all these respects the female pottery operatives are much more favourably placed than servants of an inferior class, housewives of the poor, laundresses, and needy needlewomen, none of whom are so well able, either as regards clothing, food, or wages, to resist cold and other deleterious influences as they are.

Pottery operatives, both male and female, suffer considerably from lead-poisoning; there being a proportion of 8 per cent. among male patients at the North Staffordshire Infirmary who work in potteries and 5 per cent. among the females who are so affected. This seems a favourable opportunity to consider the effects of lead-poisoning in general, and the diseases to which workers in lead are subject; since probably potters suffer from lead-poisoning as much as any other kind of handicraftsmen, except the men engaged in the manufacture of white-lead. The operatives who suffer most from lead-poisoning are: house-painters and plumbers, glaziers, dyers, japanners, type-founders and printers, whitewashers and colourers, with of course potters and the makers of white-lead. It may be mentioned, in passing, that all these operatives suffer considerably from lung affections due to the inhalation of lead dust. On being examined, lead dust is found to consist of grey blue particles, generally with rounded borders, which, as we have seen when discussing the effects of various kinds of dust, act when inhaled as the simplest form of mechanical irritant, and which affect the lungs in the manner so often alluded to in these chapters, that I shall not further describe it now.

Some interesting particulars are given by Dr. Hirt as to the diseases of the various operatives engaged in occupations which expose them to the influences of lead-poisoning. From these it appears that among glaziers the average duration of life is about 57·3 years, while out of 100 sick, 17·8 are found to suffer from consumption, and about 25 from other affections of the lungs. Among dyers the average duration of life is 63·7 years; and of the sick 40·5 per cent. suffer from lung affections of all kinds. Among house-painters the corresponding figures are 57·5 years (almost identical with the result for glaziers), and 50·6 per cent. For japanners the figures are 45 years and 36·3 per cent. (but the figures for this class of operatives are not complete); and for printers there is given an average duration of life of 54·3 years, and 45 per cent. of the illness from which they suffer is stated as being due to affections of the lungs.

Lead-poisoning may be divided into two kinds, acute and chronic, or rather poisoning induced by large quantities of lead taken at one time into the economy, and poisoning by the admission of small quantities during a considerable period. The former mode of poisoning is almost always effected through the stomach, and though I describe it here, in order to distinguish it from the second or chronic kind of lead-poisoning, has no necessary connection with the arts: the latter is chiefly effected through the lungs, though partly by absorption through the skin. The usual symptoms produced by a large dose of a soluble salt of lead are a burning and pricking pain in the throat and gullet, thirst, vomiting, colic pains, with tenderness of the stomach, obstinate constipation, cramps in the limbs, cold sweats, and in fatal cases convulsions, with tetanic spasms, such as are found in lock-jaw. The heart's action is very much diminished in frequency, and has been counted as low as 40, instead of from 70 to 80 beats to the minute. The effects of the long-continued use of preparations of lead in industrial life, or, for example, of the use of drinking water acting upon lead cisterns containing it, are manifested chiefly under two forms—painters' colic and lead palsy.

According to Dr. Guy, the *Painter's Colic*, or as it is called, from the place where it was first observed, *Colica Pictonum*, is marked by excruciating pain in the belly, and especially in the pit of the stomach. This pain is almost always relieved by

pressure; the abdomen is hard, the muscles being strongly contracted; and there is obstinate constipation, or there may be scanty action of the bowels with much suffering. The kidneys act only slightly and painfully, the countenance is dull and anxious, the skin bedewed with cold perspiration, the pulse commonly of the natural frequency, but sometimes quickened, the breathing rapid and catching. Occasionally there is fever. The colic sometimes comes on without previous symptoms of disease, at other times it appears after long-continued indigestion and disorder of the bowels. The sufferers may either recover completely, or they may become affected by the second form of chronic poisoning—Lead Palsy. In rare instances it terminates in a species of apoplexy, which comes on with giddiness, extreme weakness, and torpor. As these symptoms increase, the pains in the abdomen subside, and the patient at length dies, convulsed and comatose.

Lead-palsy is sometimes the termination of a single attack of colic, but more commonly it supervenes after repeated seizures. In some cases again it comes on without any previous attacks of colic. The disease chiefly affects the upper extremities, especially the muscles of the hand and fore-arm, which first lose their power, and then gradually waste away. The loss of power is chiefly in the muscles of the back of the fore-arm, so that when the arm is raised the hand falls by its own weight. Hence the expression "dropped hand." The patient generally raises one hand by the help of the opposite arm, which is very characteristic of the loss of power in the muscles of the fore-arm and hand. Great importance is also attached to the presence of a blue line on the gums in cases of lead poisoning. This is a condition almost always found in persons who have been exposed for a long period to the influences of lead, and its presence may be looked upon as characteristic.

The reason that potters suffer from lead-poisoning is to be found in the glaze used in giving the smooth lasting surface to earthenware and china, and to a small degree in some other processes in which lead colours are used, the chief of which is what is termed "ground-laying." The men who use the glaze are called "dippers," because their work is to dip their ware in the fluid glaze. Their hands and wrists are during their work constantly wetted with the lead glaze, and their clothes and faces become more or less bespattered with it. The extent to which they suffer is largely dependent on their own care and cleanliness, but to a certain degree also upon personal proclivity to suffer; for it seems certain that the lead enters and affects the system much more in some workers than in others. One or more helpers, women or lads, are engaged by the dipper in taking the ware from him, and in wiping off superfluous glaze. Those likewise into whose hands the glazed ware comes—the "glost placers"—are also frequently poisoned by the lead.

The only other form of lead-poisoning is that induced by drinking water contaminated by being contained in lead cisterns. This subject has been carefully examined by Drs. Christison, Taylor, and Miller, who state the result of their inquiries as follows: The contact of air and water with lead forms an oxide of lead which is dissolved in the water. The solution absorbs carbonic acid from the air, and the resulting oxycarbonate is deposited in silky scales. A fresh portion of oxide is formed and dissolved, and a fresh crop of crystals deposited; and in this way the metal is rapidly corroded. The free access of air is essential to these changes, for distilled water deprived of its gases by boiling, and excluded from the air, has no action on lead. The action of air and water on lead is very rapid when the water is pure. Thus distilled water, or very soft water, or rain water, collected in the open country, left in contact with pure lead, with the free access of air, causes a very rapid corrosion of the metal; but the rain-water collected from the roofs of houses in large towns, in consequence of the impurities which it dissolves, has little or no action on lead. There are some substances often found in water whose presence increases the corrosive action on the lead; and there are others again which have the opposite effect of diminishing the action. These latter are the sulphates, phosphates, and carbonates; and bicarbonate of lime and sulphate of lime very effectually prevent the corrosive action. So small a quantity of the latter as one part in 5,000 completely hinders the contamination of the water by lead. Some kinds of water, as that of the Thames near London, that used in Edinburgh, and the water of most springs, contain so much saline ingredients as to prevent the action on lead, and so render lead cisterns perfectly safe. But the waters of some rivers and springs are so destitute of saline matters that they act powerfully on lead. It must, moreover, never be forgotten that carbonic acid gas, when present, completely counteracts the preservative effects of the saline matters above mentioned, and it is therefore better to forego altogether the use of lead for water pipes and cisterns. Slate should be

used for cisterns; and iron, earthenware, or glass for water pipes; but, if lead is used for these purposes, then bicarbonate of lime or sulphate of lime should be added to the water, or sulphuric acid which, by forming an insoluble lead-sulphate, is also an efficient protection. When any other metal is in contact with the lead, or when solder is used to join the lead plates, the corrosive action is much increased, as it is also by vegetable matters or fatty substances which tend to dissolve the lead.

The treatment of lead-poisoning can be undertaken only by doctors. In acute poisoning it will of course be proper to empty the stomach by the stomach pump, and to give antidotes. The principle of the action of the antidote is to precipitate an insoluble compound of lead. When this is done the juices of the stomach no longer act upon nor dissolve the lead, and any further poisoning at once becomes impossible. As readers who are acquainted with chemistry will be aware, the sulphate of lead is quite insoluble, while lead and sulphuric acid have a very strong affinity to combine with one another, and form lead sulphate. Hence the principle of treatment is best carried out by the administration of a harmless sulphate such as that of soda or magnesia (Epsom salts), the sulphuric acid of which combines with the lead to form a compound no longer capable of doing any harm. The treatment of chronic poisoning must be conducted on different principles, which are rather beyond the scope of this work; but it may be mentioned that most doctors, if consulted on this point, would probably recommend the administration of iodide of potassium three or four times a day. To prevent the hurtful effects of working in lead, chemistry ought to be able to devise some means; but greater personal cleanliness would no doubt greatly aid her endeavours.

The potters' asthma, due to the clay dust, could be best obviated by the measures already advocated for diminishing the evils arising from dust in general. These are: fans for removing the dust, and the use of respirators by the workmen. In those parts of the potter's art requiring the use of the grinding-wheel, much good has been effected by the use of water, to wet the wheel. This has the effect of clogging the dust, and so preventing its being carried by the air into the lungs of the operatives.

MODEL ESTABLISHMENTS.—VII.

THE ROYAL SMALL ARMS FACTORY, ENFIELD.

By Robert Smiles.

ANYONE who has an opportunity of comparing ancient arms with those of modern manufacture, will be surprised that there is so little of novelty in the essential characteristics of the weapons of precision of our time, and will be led in the direction of believing, with the wise man, that, "the thing that hath been is that which shall be; and that which is done, is that which shall be done: and there is no new thing under the sun." The "roaring culverin" of the olden time was the true progenitor of the modern cannon, with the important difference that the "infant" greatly surpasses his sire in size and weight. The "wall pieces" and rampart-guns — the connecting link between artillery and small arms—had important features common to both. The "arquebus," or hooked hand-gun, resembled in essentials the muskets and rifles of modern times, as did the "petronel," the parent of our horse-pistol.

It is probably a prevailing belief that rifling the barrels of large guns and small arms, and loading the pieces at the breech are modern improvements. But such is not the case; each of these principles of construction was known and practised centuries ago. Rifled small arms, with match-locks and wheel-locks, date from, at least as far back as the time of Henry VIII., *circa* 1522, and an example is extant of a wheel-locked arquebus of the same period, breech-loading, upon something strongly resembling the Snider principle; one, or more, double-barrelled, rifled, breech-loading wall-pieces are also in existence, that date from the time of Louis Quatorze, about 1643. Percussion, as well as flint locks, were known as early as the time of James II., 1685–8; in the time of William III., wheel-lock carbines were made with barrels 24·75 inches long, and of ·766 inch calibre; also wheel-lock petronels, with similar barrels. The long muskets served to the troops from that time down to the present century had 39-inch barrels, calibre ·753 inch. The Brobdingnagian arms, known as rampart-guns, or wall-pieces, although fired upon a

tripod or other rest, were fashioned with butt and stock as huge muskets; they had barrels from seven feet long upwards, with calibres of from about ·650 inches, to ·860 inches. The match and wheel-lock guns of the sixteenth to the eighteenth centuries had barrels of from 48·7 inches to 39 inches in length, and were of about ·764 inch calibre.

The date of 1552, given as that of the introduction of rifled arms, is quoted because at that time Danner, of Nuremberg, was supposed to have perfected the rifle, but this mode of treating the barrel was practised previously. In 1848 a rifled gun was taken from the Hungarian insurgents, which bears the date 1547. It has six well-cut grooves, that have a twist of one turn in twenty-six inches. The Danes were armed with wheel-lock military rifles, as early as 1611. Among the old arquebuses that have been preserved, some of which are beautifully finished arms, there is one, of date 1690, that has a double-action lock for match and flint. The Palliser principle of lining the bore of a gun with an iron or steel tube was known to the Danes at a very early period. The American breech-loader of 1856, and the Krupp field-guns of the present day, are, as regards the breech action, on precisely the same principle as a wall-piece of date 1690. A rampart-gun of 1619 anticipates the essentials of the Martini lock. A bronze gun from Lucknow repeats the arrangements for breech-loading of the rampart-guns of the time of Louis XIII., about 1610, and again, an existing six-chambered revolving petronel, two hundred years old, is constructed on precisely the same principle as Colt's revolvers. Chinese guns have been preserved that are almost exactly the same in the breech-loading parts as the wall-pieces of the time of Edward IV., about 1461. Wheel-lock arquebuses were used by Napoleon I.

The Royal Small Arms Factory at Enfield is not as easily accessible as many of the other sights in or near London, and the operations carried on in it may not be very familiar to the general public. It is open to visitors on Mondays and Thursdays, and is only a short distance from the Ordnance Factory Station, on the Cambridge branch of the Great Eastern Railway. The factory cannot by any stretch be regarded as a sacred place or a holy shrine. It, nevertheless, receives the visits of many pilgrims from Occident and Orient, that have come from far countries, and are careful to see this model establishment before they return. It cannot be surprising that the operations of a place where arms of precision are manufactured, of the best kind, in the most efficient manner, and on the largest scale, should be objects of interest to the natives of "civilised" countries that take much interest in "guns and gunnery." We have reason to believe that there is a consensus of opinion among foreign visitors that Enfield Factory is the most perfect of its kind with which they are acquainted, or of which they have ever heard, for efficiency of management; ingenuity of automatic machinery; admirable arrangements, and accommodation provided in the various workshops and premises; and the perfection, cheapness, and quality of the productions, with the celerity that characterises the various operations.

The factory closely adjoins the river Lea, and the Lea Conservancy navigation, with which the works are connected by a fine basin in front of the office and other buildings near the entrance, and by a branch, with about a third of a mile of wharfage, furnished with three cranes, capable of lifting from fifteen to twenty tons each. The first impressions likely to be produced upon the mind of the visitor are admiration of the cleanly and sprightly appearance of all he sees, including the pretty water basin, ornamental as well as useful, in the centre of the square, with its clean stone coping all round. He is also likely to be struck by the care and taste manifest in the condition of the pleasant garden-ground in this part of the premises. Anticipating entering any of the shops, it may be said here, once for all, that, throughout, they are as scrupulously clean as whitewash, sweeping, and scrubbing can make them, and the nature of the processes carried on will permit. The grounds occupy an area about 475 yards long by an average of 150 yards wide, or, stated freely, about 15 acres.

Muskets were made at Enfield in small numbers by hand labour, about half a century ago, but it is only within the last quarter of a century that it has become of any account as a Government factory; and that its superb equipment in self-acting machinery has been developed. Up till 1825 "Brown Bess," with a flint-lock, continued to be the arm with which British infantry were supplied. The flint and steel were converted into percussion locks about that time—1825, but percussion locks had long before been known and used by the Russians. In the percussion principle introduced by Westley Richards in 1831, he made use of detonating *pellets* instead of caps. Prior to 1820, very beautiful breech-loading sporting rifles were made in England, but they had nothing better

than the old flint-lock: George IV. possessed some very fine rifles of this class.

Machinery, on a considerable scale, began to be introduced at Enfield for the manufacture of rifles about 1852. It was at first imported from America, and the machinery was managed for about three years by Mr. Perkins, inventor of the steam gun. Since his time the works have been managed and carried on by Government officials exclusively.

About 1852 iron-mounted percussion rifle muskets, made at Enfield, were served out to the first-class reserves. The locks were stamped "W. R. R[1] Manufactory, Enfield." The barrel was 30 inches long; calibre, ·618 in.; weight, 8 lbs. 11 oz.; charge, 11 grains; twist 1 in 40 inches. The Enfield pattern of 1853 had a barrel 39 inches long; calibre, ·577 inches; weight, 9·6 lbs.; it had 3 grooves, and 1 turn in 78 inches. These arms superseded "Brown Bess," that could scarcely be depended on at a range of 200 yards, whereas the short Martini-Henry carbines now made at Enfield, with which the artillery and cavalry are armed, will, in the hands of a good marksman, hit at 1,000 yards. Telescopic sights were introduced about 1858. Very many experimental rifles have been made at Enfield, introducing from time to time new modifications, with a view to obtaining the most effective weapon possible. Of improvers of the rifle since 1850, as is well known, the name is legion.* The rifle with which the infantry were armed in the Crimean campaign in 1855, was the Delvigne-Minié; weight, 9·31 lbs.; barrel, 39 inches; calibre, ·702 in.; it has 4 grooves, with a twist of 1 in 78 in.; charge, 68 grains; bullet, 670 grains. The 4th Division was not served with this weapon till after the battle of Inkermann. This rifle was first used by British troops in the Kaffir war of 1852. Enfield-rifled carbines were served to the artillery and cavalry in 1853. After 1866, the long and short Enfields, before referred to, were converted into breech-loaders, on the Snider principle. Most of the Volunteers continue to be armed with this rifle, but for the regulars it has been in turn superseded by the composite Martini-Henry—the Martini lock action, and the Henry barrel. This weapon having been found the most simple, efficient, and in all respects the best, is now the only pattern made at Enfield in both rifles and carbines, which are each of the same calibre, so that they may both take the regulation ammunition for small arms.

The numerous experimental rifles made at Enfield, and the modifications from time to time tried as improvements, involved the invention of new machines, or the adaptation of those in use. The Martini-Henry having been definitively adopted as the approved pattern, the occasion for experiments passed for the time, and attention was concentrated upon perfecting the machinery employed in the various operations involved in the manufacture of that weapon—the object seems to have been fully attained.

In evidence of the economical wisdom of adopting the Martini-Henry as the fire-arm issued to the troops it may be mentioned—apart from its merits as a weapon of precision—that the breech-action of the Enfield rifle had fifty separate parts; the Snider had thirty-nine; whereas the Martini has only twenty-seven, stock, lock, and barrel being all firmly connected by a strong bolt passed through the butt and screwed into the body. Another great advantage of the perfected system of manufacture at Enfield is, that every one of the fifty separate pieces in a rifle or carbine, down to the smallest screw, is so made as to fit any one of 50,000 rifles or carbines, making the work of the armourer-sergeant of a regiment, if he has stock of the parts, quick and easy.

The raw material used up in the Small Arms Factory comes under very few heads. It may be classed as walnut from North Italy and Switzerland, for stocks; steel and iron rods and bars; and coal and coke; with a comparatively small quantity of general stores. All the material is delivered under contract; the wood, coal, and coke by barges, the steel and iron, chiefly from Sheffield, by railway. The stores for the raw material are deposited in the buildings running parallel to the wharf. Following, first, a barge-load of walnut for stocks, we find that they are delivered roughly shaped. The first scrutiny they undergo, after proving the accuracy of the "tale," is the test for the presence of salt, insects, metals, or other foreign substances or imperfections in the wood. The application of the salt test is a pretty experiment. A thick shaving is taken from the butt or stock, and dipped in a glass tube containing a detective solution. If salt is present, it is revealed at once by a white precipitate that exudes from the shaving, and the piece is condemned. Corrosion would, of course, be the result of contact

* To mention a few of them:—Lancaster, Moore, Nuttall, Palliser, M. Storm, W. Richards, Whitworth, Jacob, Green, Harris, Snider, Joslyn, Burton, Henry, Peabody, Remington, Rigby, Fosbery, Sharpe, Terry, C. Shepherd, E. Baker, Witton, Maynard, Manton, Martini, &c.

between the salted wood and the steel barrel of the rifle. The presence of iron is usually detected by discoloration on the surface. In one condemned butt that we saw, there was embedded the broken point of a sword, and in another a tenpenny nail, head and all. Worms give more trouble, sometimes there are external appearances that indicate their presence, in other cases they are detected by the sense of hearing. One butt was in the store that had a worm in it heard at work more than four years since, and was still alive! These pests are shown under a glass case in about a dozen stages of development.

There are usually from 300,000 to 400,000 butts and fore-ends in store. Following the walnut to the shops in which the further processes are conducted, we witness the performances of a number of wonderfully ingenious "copying" machines. An iron butt, of the precise form wanted, is associated in the lathe with a walnut butt; by a rocking motion, a clever attachment between the original and the piece operated upon, and the action of cutters making 4,000 revolutions per minute, an exact copy is speedily produced; in like manner the fore-end is "copied," and by other tools hollowed and grooved for the barrel.

Returning to the warehouse on the wharf side, the steel and iron stores contain the variety of rods and bars of the sections suited for the parts they have to supply. The barrel-pieces for the rifles are steel bolts about 18 inches long, and for the carbines 12 inches long and 1¼ inch in diameter. They are drawn in the works to 35¼ inches for the rifles, and 22½ inches for the carbines. The boring of the barrels is effected by vertical cutters working in a long range of machines, the attendants upon which occupy a platform in line with the machines. There are eighteen boring machines, with seven spindles to each barrel—each cutter takes out its own length. The barrels are polished at Enfield by effective machinery that obviates the fatally unhealthy operation of grinding. For barrel-turning there are twenty-four machines in use, and for polishing, five machines; the latter grip the barrel with elastic hollow pads, supplied with emery powder, and have an up and down motion. One man minds four machines, and each machine takes ten barrels. The process is complete in about twenty minutes. The rifling machines have a peculiarly beautiful action; the twist is of one turn in twenty-two inches. This is given by the guide of the cutter passing along a triangular plane, that is called by the attendant an inclined plane, which it really is in effect, although moving horizontally, not on a slope. There are twenty-five of these rifling machines in use, and one barrel is operated on at a time in each machine.

We may here follow a parcel of bored barrels to the proof house, which we were privileged to enter. Every barrel is proved three times, viz., after being bored, after rifling, and at the long range when the rifle is complete. The barrels we saw tried had been bored simply, and were tested with three times the ordinary charge, *i.e.*, with seven and a half drachms of coarse-grained regulation powder. The barrels, up to sixteen in number, are laid in a very strong iron chamber, about fifteen feet long, with a descending curvature at the further end, where the bullets are directed into a trough filled with saw-dust. The trigger discharged the lot, they went off "bang," and were taken out, every one skin and heart whole. From 200 to 300 barrels are tested daily in the proof-house.

Assuming butt, fore-end, and barrel to be complete so far, there is yet a great deal to see. The smithy has 86 fires, 20 steam hammers, 8 screw drop hammers, 15 forging machines, 3 sets of rolls for making swords and bayonets, and numerous other important appliances. Here we saw the "body" of the Martini action forged in a few seconds by four blows of the steam hammer; the "block" by three blows; the "trigger guard" by five blows; the butt plates stamped, the "carbine nose cap" formed, and a number of other operations performed, that would have taken hours against seconds, if left to hand labour.

From the smithy the rough forgings of the parts referred to, go through various stages, until they reach what is called the "component part" room, one of the largest, best lit, and cleanest workshops we have ever seen. It is about 200 feet square, contains more than 1,000 machines, and 500 workmen, obviously of a superior class. Here the sights for rifles are finished with the most delicate exactitude by machinery of the most ingenious character, guided by intelligence; this is the rule indeed at every stage—effective ingenious machines and able steady men to control them.

The tool room is also a most interesting department; here all the tools, gauges, and machines used throughout the factory are made and repaired. In this and other rooms we observed many admirable, although small, slotting, planing, mill-cutting, drilling, and other machines; the clamp-milling machines and their products are especially meritorious.

The tests applied to the work in its progress are very searching, every part being tried by numerous delicate steel gauges, and rejected if found defective. Each steel barrel is stamped, and, so to say, its perfection attested, twelve times during its progressive stages. In some points the demand for accuracy goes to the attenuated shadow of the one-thousandth part of an inch!

Time would fail to tell of the operations carried on in the rooms for finishing bayonets and swords; ram-rods, or rather cleaning-rods, the breech-loader not needing ramming; for scabbard making and mounting; and the powerful sewing machines employed in this department; of the "browning" of the barrels; of the manufacture of "assegais" for the Lancer requirements; or of the operations in the stores for finished work—finished for service in peace or war in any part of the world.

Touching payment for labour, everything is paid for by the piece as far as possible. If new machines are invented, or machines in use are so improved as to produce more work, a man or two may be dispensed with, but wages are not reduced. The rates paid for different kinds of work are almost infinitely varied, and in all cases good. In making certain kinds of screws, for instance, there are nine operations; for one of these 5d. per 1,000 is paid, for another 3d. per 100. Each rifle has about fifty parts, every part requiring many operations, some of them very delicate. In a rifle barrel alone there are seventy operations, each having its separate price. All payments are worked out by decimals, and the practice is for the foremen to report at the proper time to the paymaster that numbers such and such (each man is known by his number) have bored so many barrels, or done certain other work, and the wages are made up from the report. The pay of the 2,000 men employed occupies about twenty minutes. None of the workpeople are under eighteen years of age. The hours worked are from 7 till 6 on five days in the week, and from 7 till 11 on Saturdays, or 54 hours per week.

In ordinary working 1,800 stand of arms can be made and stored per week, but under pressure nearly double that number can be turned out by working relays. Swords for cavalry, Horse Artillery, and mounted officers and men of the army, are supplied, under contract, by Birmingham makers chiefly. Revolvers are now issued to portions of the army, and arrangements are in progress for the manufacture of this weapon at the Royal Small Arms Factory.

The Factory has its own gas-works; and other supplements are, a very pretty church built by Government; a mechanics' institution, with 300 members, and a library of 2,000 volumes, with a reading room supplied with almost all the London daily and weekly papers, three American scientific papers, and the best of the reviews and magazines. There are also successful science and art classes in operation with about 50 members; a boys' school, with 100 scholars; a girls' school, with 90 scholars; and an infants' school, with 103 scholars. The educational institutions are under the inspection and support of Government, but moderate fees are also charged for attendance.

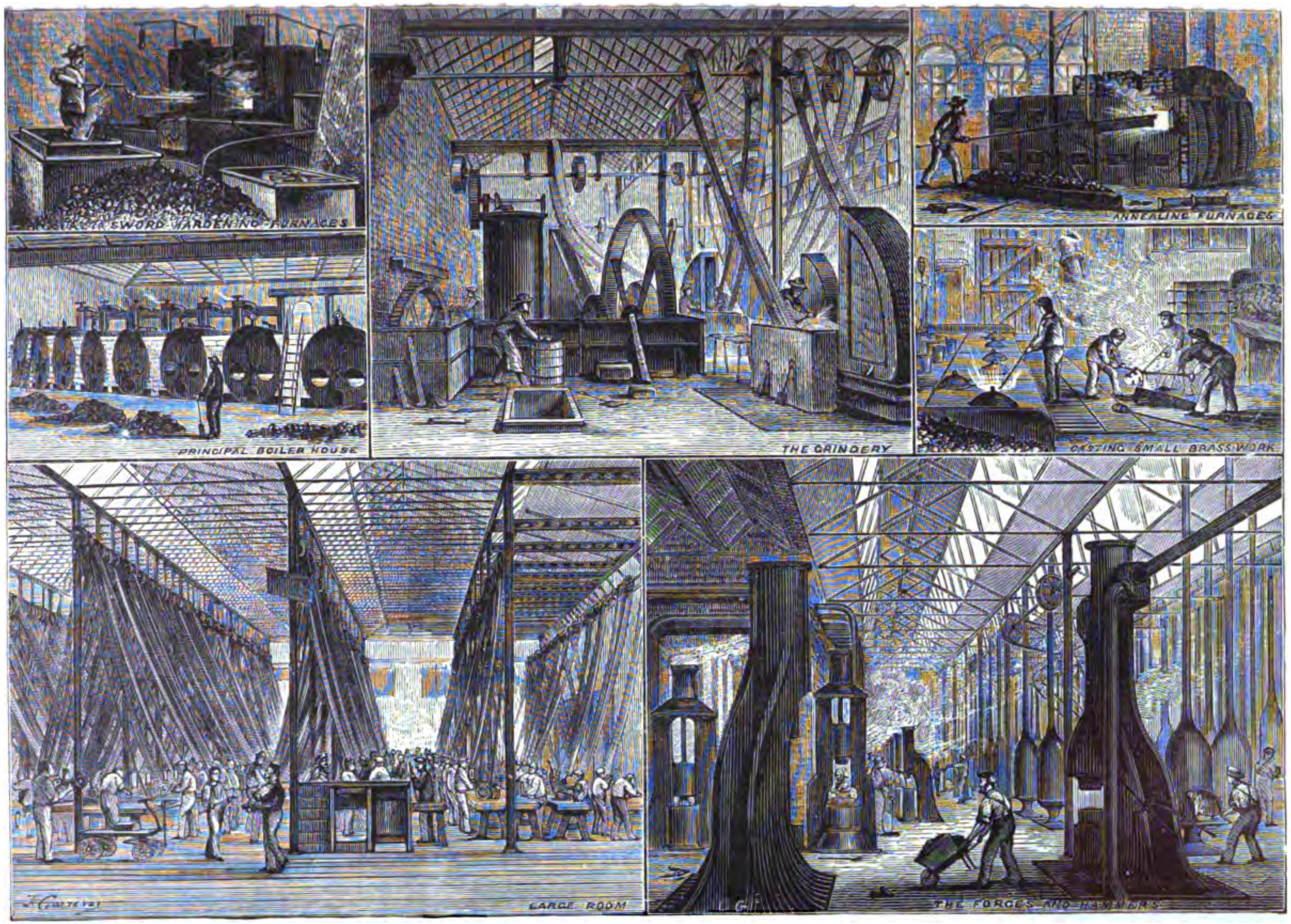
The Factory is under the superintendence of Col. H. T. Arbuthnot, R.A.; Major W. McClintock, R.A., being the Assistant Superintendent. There are also a Manager and an Assistant Manager, Mr. T. McGee, to whom our best thanks are due for his patient assistance in the tour of inquiry.

WOOL AND WORSTED.—XXI.

CASHMERE, PAISLEY, AND OTHER SHAWLS—TARTANS, ETC.

By William Gibson.

BRIDAL gifts by her Majesty to members of the British aristocracy have generally, during recent years, consisted of cashmere shawls; and although these splendid fabrics are neither so rare nor so eagerly sought for by ladies who desire to be considered leaders of fashion as they were, products of Indian handiwork have rather increased than diminished in value during the last decade or two. Until the beginning of the present century the products of the valley of Cashmere were practically unknown in Europe, and the best samples of these marvellous fabrics had only been seen by the few Anglo-Indian officials who were brought in contact with rajahs who wore them. As soon, however, as they began to be imported into the West, woollen manufacturers were, perhaps, more envious of the



Views in the Royal Small Arms Factory, Enfield.

skill displayed in their fabrication than the dame whose purse was not long enough to admit of the purchase of one of the fashionable articles of female attire. It was in France that the first attempt was made to copy their gossamer beauty of fabric, their remarkable shades of colour, and elegant designs; but in our own country not a few ambitious employers were eager to pit the skill of the enlightened Englishman against that of the ignorant Hindoo. Everything was done that ingenuity and the liberal disbursement of money could do, but all in vain. No wool which could be produced in Europe was capable, by the aid of the most delicate machinery, of being spun into threads scarcely grosser than those woven by the spider, and our dyers were at their wits' end when they compared their own clumsy endeavours to produce the delicacy of shade and the brilliance of hue that shone in the Indian yarns. Paris, Lyons, Norwich, and Paisley were bound to confess that they were incapable of turning out a shawl fit for a moment to be brought into comparison with the most ordinary handiwork of Lahore.

Nor was this to be wondered at when we take into consideration, not only the superior quality of the raw material produced by the ordinary domestic goat upon the uplands of Tibet, but the care with which from time immemorial it has been prepared for the spindle and the loom, and the length of time and ingenuity often expended by the poor weavers in the Punjab, before it is ready for the market. The finest wool is grown in the neighbourhood of Ladakh. Under the coarser hair of the goat is a short, silky, absolutely white duvet, which arrives at maturity in the winter months. The animals are shorn in the early spring. As soon as the fleece is cut it is handed over to the meek-eyed patient women of the district, who deftly and carefully pick out with their fingers all the long and coarse hairs. The duvet is then washed in a solution of lime and water, and further dried, softened, and cleansed by being shaken backwards and forwards in sacks partially filled with rice-flour, or very fine sawdust. How could the European with his dumb carding engine hope to rival the ability of the Indian women? The fleece as it comes from the goat, coarse hair and all, is worth from one to two rupees per seer (about 2 lbs.), but when picked, cleaned, and spun on the native *churka*—a spinning implement such as was used in the days of Job, and still survives in remote corners of Wales and the Highlands—the coarser kinds of yarn are worth as much as 50s. per lb.; and the finest gossamer has been sold frequently at from one-third to one-tenth its weight in silver coin, and it is the merest truism to say that when finished the fabric is worth more than its weight in gold. The yarn is now carefully dyed, and only the initiated among our dusky fellow-subjects are aware of the mysteries of this process. Some have thought that there is a peculiarity in the water of the Punjab which accounts for the brilliancy and delicacy of the hues and minute shades, but it is far more likely to be accounted for by the superior character of the dye materials, skill in making the bath, and care in dipping and dyeing the yarn. A good deal too, no doubt, may be said for the climate and atmosphere in that part of the world as an assistant of the dyer; but when all this is admitted there yet remains much calculated to make our skilled dyers ashamed of their want of success, for although we have those marvellous aniline colours at command, we are even yet unable to approach the tone, clearness, and richness of the true Cashmere shawl. And then when we turn to the weaving of those unapproachable textures, and think of the almost imperceptible progress made in a week or a year, we cannot wonder that the production of such works of art is impossible in regions where rapidity is so much thought of that the quality of the article manufactured is but a secondary consideration. Cases are by no means rare in which every male member of a family for two generations has been engaged during his entire lifetime before one first-class *rizai* has been completed. The true cashmere is of two sorts—woven and embroidered. The former are either made in one piece by three or four workmen at the same loom, or in parts by different weavers on separate looms. The latter are embroideries of gold and silver, intermixed with beetles' wings—a task hopelessly beyond the most skilful operative in the far-famed Gobelins factory—upon plain woven cloth dyed red or green, or left in all its native snowiness. Both kinds are triumphs of skill and art, but the former are most in repute. Each shade in the pattern is worked with a separate needle or shuttle, the reverse side of the design uppermost. When a new pattern is being produced, one man sits behind the operative or operatives, with the artist's drawing in his hand, and dictates the number of stitches to be taken, and the colour to be used. When the workmen have learned the pattern by heart, as they very soon do, they can of course dispense with assistance, and the labour progresses rather more rapidly, if

such a term can be used when the advance made by four persons during a long day's constant work is less than a quarter of an inch of the length of a shawl. Where the shawl is made in parts by different weavers it is afterwards sewn together so deftly that the junctures are almost invisible, and could not be suspected by any one not in the secret. As long shawls are usually 54 inches wide, by 126 in length, it may easily be computed that one takes years to complete from the time the fleece is shorn off the goat till the garment is exposed for sale in the bazaar. Square shawls are usually 63 inches by 72. Sometimes, however, the sizes vary, especially those made at Umritzur and the neighbourhood. Ladies' shawls there are generally three yards and a half, by one and three-quarters—turbans two yards by two—and *jamawar*, or garments, four and a half yards by three. The value of these shawls varies from £200 to over £1,000, according to size and fineness, purchased where manufactured at first hand, and these rates are of course increased as they pass from merchant to merchant. Very few of the true shawls are now made in the valley of Cashmere compared with the first forty years of the century. Whereas at the beginning of the century there were 6,000 looms at work, there were in 1850 less than half, and the value of the woven products sank from half a million sterling per annum to about £170,000 in the latter year. The reason for this decline was that in 1843 a severe famine took place in Cashmere, and the workmen migrated in search of food to the Punjab. Many of them settled down in the neighbourhood of Umritzur, and there the manufacture is chiefly carried on at the present day. As the true Cashmere goats about Ladakh do not number much more than 100,000, and the finest wool is got only from the neck and underpart of the body of the animal, many imitation products came into the market as the demand for the rarity increased in Europe. In consequence of this one of the rajahs was obliged, not only to limit the output, but for the sake of the renown of the district to lay down rules for the manufacture. The size of the shawls, turbans, and jamawar was carefully scaled; any shawl badly woven was impounded and destroyed. Designers might sell their patterns, but no part of the original idea was to be retained, nor was any variation of the original drawing permitted. One designer was forbidden to sell his idea to another, and not more than six shawls were to be woven from the same pattern under severe penalties for any breach of the rules.

What has been said above may help the reader to understand the difficulties that met the Europeans desirous of imitating the products of the Punjab. But serious as were the drawbacks, so greatly did the demand for anything in the shape of real or imitation cashmeres become from 1820 to 1830, and so large were the prospective profits to be gained, that an enormous impulse was given to this class of manufacture. The first person to set up a cashmere factory was a Frenchman named Jaubert, who opened premises in the Faubourg St. Antoine, Paris, in 1817. He imported a flock of Tibetan goats which, after some trouble, were acclimatised at St. Ouen, but as the wool was much inferior to that grown on their native hills, the raw material had to be imported from Asia. Then, finding that the French dyers were unable to compete with the Hindoos, dyed yarn was brought over at enormous outlay, the best artists were employed to imitate the patterns, and the most skilled workmen to reproduce them in cloth; but it must be confessed that the result was not very gratifying. The French cashmeres, however, sold readily and at good prices, and the Norwich manufacturers, not willing to be beaten, tried to transfer a portion of the trade to England. All kinds of delicate and ingenious machinery were speedily designed to increase the rate of production; and, by mixing the warp yarn with silk, wool of the finest texture came into use gradually, instead of the costlier yarn from India. At first the patterns were wrought out by hand, as in the original seat of manufacture, but in course of time the Jacquard machine began to be estimated at its proper value, and a loom was designed for making this class of pattern goods. The great difficulty experienced, however, was that the shuttles of various coloured warp—instead of passing from selvage to selvage, as in the case of damask or diaper, where the flowers are thrown up in a uniform tint throughout the web—had to enter at the selvage, stop at a certain point in the width to take up the pattern further on, and be succeeded with one or more at longer or shorter intervals. While the Jacquard raised the requisite warp threads for each "pick," the weaver had to employ one or two assistants, throw the minute shuttles, according to a coloured pattern in front of him, and leave the threads to appear on the reverse side loose. These threads were afterwards cut and shaved with the rest of the pile, but the ends were always visible, and, of course, lessened the value of the article. Afterwards an attempt was made, by multiplying the warps, coloured according

to the requirements of the pattern, to throw up the figure over a homotoned weft. In this class of goods, however, the surface was uneven, and did not present the glossy and uniform appearance of the real Indian work. Yet shawls woven by this process were wonderfully successful, though it was impossible to employ more than four or five tints, and the mounting of the looms was so very difficult as to rise to the dignity of a fine art, whereas in many of the cashmere patterns as many as fourteen or sixteen colours and shades were used, so that the western shawls looked plain and common beside those of Hindostan, however fine the texture and excellent the workmanship. By successive improvements in the mounting of the looms, and especially a mechanical contrivance invented by M. Eck for throwing the multitudinous shuttles—so small that from ten to twenty could be manipulated in the space of a couple of inches of the width of the piece—diagonally, instead of at right angles to the warp, not only was the beauty of the real Indian work imitated, but an incredible saving of time resulted. All this, as may be conceived, tended to cheapen the fabricated article, and quicken the demand. The consequence was that this class of manufacture increased with giant strides, and enormous fortunes were realised by the best-known houses. Even at the present day these imitation shawls range at prices between forty and a hundred and fifty guineas, or even more for some classes. French manufacturers succeeded more easily with embroidered goods, and large quantities of these are yearly sent into the market. Successful attempts have also been made in weaving portions of patterns and joining them afterwards, but at best the French shawls, when compared with genuine Oriental work, are, as the poet says—

> "As sunlight is to moonlight,
> And as water is to wine."

As we have already stated, the Norwich manufacturers tried for a time to compete with those on the Continent, but whether it was that the necessary outlay of capital demanded was too great, or that the English workman was inferior to his French brother in taste, skill, and patience, it is certain that the struggle was not maintained for any length of time, nor was the superiority of the foreign article ever in serious doubt. Besides, Norwich had gained an enviable notoriety for other kinds of woollen fabrics, and capitalists soon found it advantageous to leave fancy work for the equally lucrative home products. The idea once mooted, however, it was not consistent with insular pride that we should at once give up the struggle. From Norwich the notion travelled to Edinburgh, where it languished for a time—like a tropical plant in an unkindly atmosphere—and finally found its way to Paisley, where it eventually became indigenous under somewhat modified circumstances. In the ancient seat of the English woollen industries, and in the metropolis of Scotland, it had never been considered that a new product, like that of cashmere, and yet different, might be attempted with success. Some weavers in Stockport first conceived the idea of producing shawls in silk, and a lady in Edinburgh, who was famed as an embroiderer, produced in silk and fine wool a worked shawl. All this set the "Paisley bodies" thinking, and the result was just what might be expected, when the long-headed, pertinacious men of the West take a subject up.

How the fact that cashmere shawls existed got as far as Paisley early in the present century, when travelling was so slow, and packmen were the chief travellers in that part of the country, it would be difficult to say, but in all likelihood some enterprising pedlars from Norwich or Stockport might have carried samples of the new fabric in their wallets, or perhaps even a coarse Indian shawl might have been imported by some of the rich citizens of Glasgow, and the fame of the French imitations might have been carried to Saint Mungo's city. Paisley had, from the beginning of the eighteenth century, been noted for its silk gauze, muslins, and fine checked linen, and spinning as well as weaving in that town had been carried to greater perfection than in any part of Scotland. Among those in the Renfrewshire town to whom the new kinds of woven articles had been shown, was a well-known manufacturer named James Paterson, of Orchard Street. He set to work, and, by aid of a complicated "harness" loom and a draw-boy, turned out in a few months a cashmere-pattern shawl in soft silk, then one in spun silk and cotton, and, finally, one a mixture of all three materials. The ball once set rolling continued, the pride of the "websters" was pricked, and the outcome of various trials was an imitation shawl, the warp of which was spun silk, and the weft a thread of fine wool and silk waste mixed. This mixture, which at once caught the public taste, was called "Persian cloth."

As the French cashmere became better known, some Yorkshire manufacturers began to devise machinery for weaving a finer woollen texture than had hitherto been attempted, and after a time, a Bradford house hit upon a twilled cloth woven with the finest Saxony yarn, which was scoured,

bleached, teasled, cropped, and sent into the market under the name of Tibet cloth. In course of time, however, the texture grew finer and finer, and the twilled surface was but slightly raised or cropped, a fringe of silk, or silk and wool, was added, then a flowered border was embroidered, and finally a cashmere border was printed on this material, the centre remaining white, and these goods became very fashionable.

The Paisley and Yorkshire woollen centres were intimately related in business transactions, and all that went forward in one district was known in the northern town. While the Scottish weavers were busily engaged perfecting their imitations of cashmere shawls, therefore, the new Tibet cloth suggested the fresh solution of a difficulty under which they were labouring. Up till 1830 Paisley was obliged to import cashmere yarn from France, and the manufacturers of that town were gradually becoming more expert in the weaving of the fine Oriental border ornaments. But the French yarn was very dear, the cost of carriage and duty ran away with a large slice of their profits, and after all why should they not improve their spinning jennies so as to twist higher numbers, and so approach the foreign fineness of thread? There was no probability of rivalling the genuine cashmere, but might they not attempt a coarser product? and was not the Yorkshire Tibet cloth just the thing they required? Messrs. Roxburgh, the well-known harness weavers of Paisley, tried borders of the Yorkshire yarn, which was cheaper, and had the advantage of being a home product, and they found it answer very well. They subsequently—in 1830, we believe—introduced Cabille yarn, all wool, of their own manufacture, and the shawl border business grew apace. Only one step more was required to perfect the new kind of shawl, which everybody had been trying for in the Renfrew town. Paisley borders were unrivalled, but its weavers were less successful with the plain centres than those in Yorkshire. Why not make a compromise and a combination? This was done; the cashmere centres were got in Yorkshire, chiefly from Bradford and neighbourhood, the Paisley borders were sewn to these centres, and the "harness shawl," that has retained its popularity for fifty years, came into existence. The white

CASHMERE GOAT.

centres, for the sake of variety, were dyed red, and subsequently other shades, and in course of time the Yorkshire manufacturers succeeded in producing a cloth white on one surface, and red or some other shade on the reverse side. With this new class of goods numbers of clever draughtsmen were attracted to the place, and simpler but still wonderfully effective patterns introduced, and less difficult to weave, as they demanded fewer colours. The harness loom and the attendant draw-boy long remained popular in Paisley, and consequently the factory system was later adopted here than in any other centre of industry. Each weaver had his own loom, winder, and draw-boy, often his own shop. When his workshop was large enough to admit of more than one loom, the proprietor rented a part of it to some less fortunate weaver, or in case he possessed several looms, the owner of a house rented these to journeymen weavers, who could thus, without possessing capital, earn a respectable livelihood. Some of these Paisley weavers were remarkable men—shrewd, keen, Radical politicians, uncompromising Dissenters, and able workmen. Frequent and well-contested were the political or religious discussions between occupants of the same "loom-shop," as may be seen in the extremely clever bundle of reminiscences by David Gilmour, published a few years ago. But though Paisley shawls are still made, trade has seriously declined. In 1818, when that town had 35,000 inhabitants, some 7,000 weavers and 5,000 draw-boys were employed, but in 1874, although the population had increased to 50,000, there were only 1,750 weavers in the place. The value of shawls made in 1834 was something like a million sterling, but in 1874 it was only a tithe of that sum. For all fashions wane. When the wool of the llama had been mastered by Sir Titus Salt, plain shawls of a uniform shade, with patterns printed upon them, came into vogue, and similar articles in merino were not uncommon. Yet in after years other kinds, woven in plain, and what is popularly known as "fleecy" wool, seem to have been preferred.

Her Majesty's annual sojourn in Scotland, and her adoption, to some extent, of the national costume, gave an impetus to a fashion which, some years before her visit to the North, began to prevail. The Rob Roy tartan, for some reason or other, sprang into unusual favour, and dresses, ribbons, shawls, scarfs, and stockings of that pattern were universal north of the Tweed. Being a simple check of stripes, alternately red and black, it was easily woven on the power loom, and became proportionately cheap. Perhaps this turned the attention of people to tartans generally, and within a few years they were to be seen as frequently in England as in Scotland—at any rate in the shape of shawls. But the Rob Roy *furore* subsided almost as suddenly as it rose, in consequence, it was said, of a famous murderess having been hanged while wearing a shawl of that pattern. Be that as it may, the taste for checks was introduced, and manufacturers, finding that the stereotyped clan patterns did not suit the taste of the fair sex, began to invent fancy checks in all sizes, varieties, and colours. Combinations were rendered comparatively inexhaustible, as the new tints in aniline colours were multiplied. Fine wool for summer wear, and coarser material for winter, shawlettes to throw round the shoulders indoors, in similar designs, followed, and they still seem to retain their popularity.

These varieties of shawls are practically produced in the same way as tartans. Different coloured yarns in due proportion are arranged in beaming the warp chain, and when these chains are mounted in the loom they present a series of stripes running the whole length of the web, and accurately repeated to a thread from selvage to selvage. The old hand-loom weaver had merely to count how many threads of each shade it took to make the stripe and repeat this as he worked in the weft, the result, of course, being a series of checks exactly corresponding throughout the piece. It needed but a slight modification of the power loom to adapt it to this kind of work. Instead of a shuttle-box capable of holding one shuttle, one containing as many compartments as there were colours in the check was constructed. By a simple piece of mechanism, this box was raised or lowered as the case might be. The colour of which the requisite number of "picks" had been woven was thrown out of gear, the next colour brought to a level with the shuttle race till it played its part, and so on till the pattern was complete, when the process began *de novo*. Of course, such an arrangement was rendered possible on account of the required changes of shuttles recurring without variation in a given order; and once the indicator was set, the loom to which it was attached would produce a given tartan without mistake as long as the demand for it continued. Messrs. Macdougall of Inverness are probably at the head of the tartan weavers in Scotland, and they have long been honourably known for the excellence of their textures.

Closely allied to the tartan manufacture is that of coarse woollen checked fabrics for the lining of overcoats, horse rugs, and kindred materials. Here, the patterns are simpler, but the machinery is the same, and the chief seats of this branch of the trade are Glasgow, Paisley, and Kilmarnock, in Scotland, and the Yorkshire woollen districts. We might easily multiply examples of various checked and flowered products, but we have indicated the chief of them, and there is nothing peculiar enough in any of the other branches of the trade to require comment.

FOREIGN RIVALRIES.—XII.

FOOD INDUSTRIES.

By H. R. Fox Bourne.

IN buying foreign wheat and flour to supply the deficiencies of its own markets the United Kingdom spent, in round numbers, £15,500,000 in 1863, £20,000,000 in 1870, and £40,000,000 in 1877. For foreign cattle and sheep, fresh, salted, and preserved meats of all kinds, and various animal produce, of which butter, cheese, and eggs were the principal items, it paid in the same years respectively about £11,500,000, £19,500,000, and £35,500,000. The increase of imports has not, of course, been in regular progression from year to year, as in seasons of scarcity in the home supply the demands we have had to make on the resources of other countries have been greater in quantity and generally yet greater in value than in the seasons when our crops have been plentiful and our herds healthy and prolific. Thus our imports of corn and flour ought not in 1877 to have exceeded £28,000,000, and those of animal food should have been, according to the average, about £38,500,000. With that correction, however, the above figures indicate with rough accuracy the growing inability of the country to sufficiently feed its inhabitants, and the extent to which, more and more every year, it will have to look abroad for the means of keeping them alive. The increased cost of living, in fact—due partly to the advancing price of many commodities, and partly to the greater taste of the people for more wholesome, if not more luxurious, diet—renders the progression very rapid indeed. Our population of twenty-nine and a half millions in 1863 consumed more of the staple articles of food just enumerated than it could produce to the amount of £27,000,000, which may be taken as the expenditure required for maintaining about three and a half million more people than our own farmers could feed. Seven years later a redundant population of five millions necessitated an outlay of nearly £40,000,000, and after another lapse of seven years the redundant population, grown to seven and a half millions, called for an outlay of more than £75,000,000, which, if the home supplies had been at their average, would have exceeded £66,000,000. At the same rate of progress we may expect to have in 1890 some fifteen million more mouths to fill than food can be found for at home, and whose wants will have to be supplied at a cost of at least £120,000,000, which is a very considerable proportion of our total exports of every kind at the present time. If our manufactures grow and the value of the exports increases with them, we may not only be able to pay for this immense supply of foreign food, but our nation may be in every way more prosperous for its numerical enlargement. It is clear, however, that very much depends on our manufacturing and commercial progress, and the risk we run in having thus to rely on other countries for so much of our food must never be overlooked.

It is urged, of course, by land reformers and others that improved methods of cultivation, to be brought about by improved systems of land tenure as well as by the extension of scientific appliances, would enable the 16,000,000 or more acres which in Great Britain and Ireland are devoted to corn and green crops to be made far more productive than they now are. That is not a question to be discussed in these pages; but it should be noted that the opinion is not shared by as competent a critic as Sir James Caird. He points out, in his work on "The Landed Interest and the Supply of Food," that the steam ploughs and the reaping and other machines, as well as the new kinds of manure, which have been introduced during the last thirty years, have tended rather to lessen the toil and enhance the comfort of our agricultural labourers than to increase the productive power of the soil. Already we get far more

per acre out of our corn-fields and our pasture land than any other country does, and we may not reckon on being able to get much more without resorting to such expensive processes as will make the additional produce unprofitable. Unless some unexpected change occurs we seem to have reached something like the maximum of home production in obtaining from our own land the present average of 55,000,000 cwt. of wheat, and 120,000,000 cwt. of other grain, to which we already have to add about 55,000,000 cwt., or an equal quantity of the former, and nearly 50,000,000 cwt. of the latter. It is a significant fact, moreover, that during many years past there has been a steady decline in the extent of ground sown with wheat and other grain. Our farmers are finding it more profitable to use much of their land for pasturage than for crops, though in spite of that, as the few figures that have been quoted show, our demands upon foreign countries for animal food are increasing every year even more rapidly than our demands for wheat and flour. "The production of bread and meat within these islands," says Caird, "appears to have nearly reached its limits. The dairy and market-garden system, fresh milk and butter, and vegetables, and hay and straw are every year enlarging their circle around the seat of increasing populations. These are the articles which can least bear distant transport, and therefore are likely longest to withstand the influence of foreign competition. This country is becoming less and less of a farm and more and more of a meadow, a garden, and a playground. The forests and moors in the higher and wilder parts of the country, and the picturesque commons in the more populous districts, are already, in many cases, not only more attractive, but more remunerative in health and enjoyment than they probably would be if subjected to costly improvement by drainage or by being broken up for cultivation. The poor clay soils, which are expensive to cultivate and meagre in yield, will gradually be all laid to grass, and the poor soils of every kind, upon which the costs of cultivation bear a high proportion to the produce, will probably follow the same rule."

The growth of corn and its conversion into bread, and the breeding of cattle and other animals in order that we may have meat to eat, are the most important of our food industries. The foreign rivalry to which our farmers are subjected, however, does them far more good than harm, and brings nothing but benefit to all other classes of the population. It is an unqualified advantage to us that in these respects other nations are able to compete so successfully with us as to furnish in abundance what we need to supply our own deficiencies. So long as we can profitably exchange for these necessaries of life our cotton, woollen, and linen goods, our steam-engines, and hardware of all sorts, there is nothing but gain to us in our obtaining corn from America, Russia, and other parts of the world which now produce it cheaply and in far greater quantities than they require for their own consumption; and it is altogether satisfactory that, in addition to our supplies of live animals from the other side of the German Ocean, new industries are springing up by which we can be furnished with prepared meats from across the Atlantic and even the Pacific. The salted and fresh beef which we imported in 1863 was worth only £2,437; in 1870 its value was £96,042, and in 1877 £1,434,234. In the same years the amounts paid for meat preserved, but not salted, were £8,092, £231,860, and £1,434,234. These are trades lately started and still in their infancy. The progress of a trade long established is shown by the fact that, paying £2,750,397 for bacon and hams in 1863, our imports had risen to £6,889,354 in 1877, having been as high as £8,611,329 in the previous year. In other articles, even in dairy and market-garden produce, which are now more profitable than any other of our food industries, the growth of our foreign trade is almost as remarkable. Of cheese and butter we now import more than we produce; the supply of the former, chiefly from America, having risen in value from £1,886,887 in 1863 to £4,771,393 in 1877, and that of the latter, from France as well as the United States, from £4,537,157 to £9,543,332 in the same years. At those intervals, also, we spent upon foreign eggs £673,638 and £2,473,377, upon foreign potatoes £240,507 and £2,348,749, and upon foreign fish, exclusive of that caught by our own fishermen in near and remote waters, £330,591 and £1,640,259.

In the case of preserved meats and such manufactured food as cheese and butter, the preparation for use must necessarily be effected at the place of production, and it is the same with articles of exclusively foreign origin, like tea and coffee, rice and raisins. If imported at all, they must be imported in a state ready, or almost ready, for consumption, and, except as regards the slight extent to which they may interfere with native produce, which can bear no comparison to the service rendered to the community by their being made cheap and plentiful, they in no way affect English industry. It is otherwise with commodities which, though

coming from abroad, we have been accustomed to prepare at home for our own use, and even for re-exportation in a manufactured form. Of such commodities sugar is the chief; and the serious injuries done to our trade in it by foreign competition are worth considering, especially as those injuries have been made special use of by some of the sufferers and their theoretical supporters in attacking the free trade policy of England.

For more than a century sugar-refining has been an important industry in England. The first cargo of West Indian sugar having reached Bristol from Barbadoes in 1646, the total imports of the country amounted to only about 10,000 tons in 1700, but a small part of which came from our own colonies. The trade steadily increased after that till 1872, when we imported more than 750,000 tons, of which about 95,000 tons came from the British West Indies. The import trade, indeed, has continued to grow very rapidly. Whereas in 1863 we imported and retained for home use 528,372 tons, the quantity had risen in 1877 to 969,965 tons. The West Indian planters, however, represent that so large a portion of this comes not only from Mauritius and other tropical countries, where the sugar-cane thrives, with which they are prepared to compete, but also from France, Germany, and Belgium, where beet-sugar is produced, that they are, if not driven out of the market, forced to sell at such low prices that they can barely realise any profit at all. That complaint, of course, refers especially to raw sugar. What more concerns us at present is the complaint of the sugar-bakers in Bristol, Glasgow, Liverpool, Whitechapel, and other parts of England, who urge that during the past few years they have been nearly all ruined by the competition of the French and Dutch refiners, who have been enabled, by the foreign bounty system, to sell their produce in such great quantities and at such low prices as to cripple our export trade and to make havoc of the markets at home. There is undoubtedly much truth in the allegation. Statistics are not forthcoming as to the quantities of raw sugar which are refined in England from year to year, but we know that while we imported only 13,564 tons of refined sugar in 1863, we imported 162,760 tons, or just twelve times as much, in 1877. During the same interval the exports of English refined sugar were from 13,938 tons in 1863 to 55,952 tons in 1877; but those figures show that, our exports being in excess of our imports by 374 tons in 1863, our imports were in excess of our exports by 106,808 tons in 1877.

The sugar-bakers may well be alarmed at that revolution—or, rather, far more than alarmed—since it appears that more than nine-tenths of them have already had to close their factories. Their case is certainly a very hard one, and the English community at large, as well as the individual sufferers, may reasonably protest against the mischievous and dishonest policy of the French, Dutch, Austrian, and other foreign Governments that, not content with imposing a duty of about 30s. a ton on all English sugar brought into their countries, grant a bounty of from £3 to £5 a ton on all the exported produce of their own sugar-bakeries. The duties may be to some extent justified on the plea that they, or some equivalents pressing on other commodities, are required in order to raise the necessary revenues. The bounties are inexcusable instances of protection in its most obnoxious form. They are direct surrenders of revenue in order that native industry may be fostered by artificial means, and will, of course, be abandoned as soon as they have served their purpose.

It must be remembered, however, that injurious as this protectionist policy is to our sugar-bakers at home and to our sugar-planters in the colonies, it is only an objectionable adjunct of the development of the beet-sugar trade of the Continent, of which we have no right to complain on principle, and which in its effects is very beneficial to England at large, though not to the English traders especially concerned in it. In 1868 the average wholesale price of sugar of all sorts was £38 a ton, or rather more than 3¾d. a pound; in 1878 it was £25 a ton, or rather less than 2¾d. a pound. In 1868 the average consumption of each person in the United Kingdom was forty-two pounds; in 1878 it was about sixty-six pounds. At an additional outlay of only 2s. we are thus able to consume twenty-four more pounds of sugar now than we did ten years ago; or if we limited our additional consumption to fifteen pounds, it would cost us nothing extra at all. In other words, the Continental sugar trade, by increasing the supply and lowering prices, has virtually enabled each of us to obtain every year fifteen pounds of sugar for nothing, or, if we use no more than we did in 1868, to save or spend on other commodities about 3s. 6d. The bounty system has, to a small extent, contributed to that result; but the reduction is mainly due to the Continental sugar trade, which has grown with amazing rapidity under healthier conditions than any bounties can supply, and which their withdrawal cannot seriously disturb.

The sugar-yielding properties of beet-root were pointed out as far back as 1747 by a German chemist, named Margraf; but no sugar appears to have been made from beet-root, for purposes of trade at any rate, till just half a century later. The commercial value of what was looked upon as little better than a weed might still have been disregarded had not the first Napoleon's attention been called to it as a means of enriching France and injuring England. By all reasonable and unreasonable methods he encouraged the cultivation of beet and the manufacture of sugar from it, and the same policy was pursued after his overthrow. Beet-sugar produced in France was exempted from all taxation, and prohibitive duties were laid on every kind of sugar. By these means the trade had sickly growth until 1832, when 9,000 tons, about a ninth of its whole consumption, were manufactured in the country. The abolition of slavery in the British colonies, throwing their staple industry into disorder, helped the French trade more than any protective laws could do, and in 1842 the native supply of sugar had risen to 35,000 tons, or about half as much as was imported. In 1842 a small excise duty was imposed, which in 1847 was made equal to the duty on foreign produce. The trade, however, was by that time so firmly established that it continued to grow, and in 1875 the yield in France exceeded 440,000 tons, the value of the industry which had been planted seventy years before being then valued at £25,000,000 a year. That the neighbouring countries, with soil as suitable for the cultivation of beet-root as that of France, should emulate its success was only to be expected. It was estimated in 1873 that about 1,100,000 tons of sugar were produced in Europe, the produce of the rest of the world being about 2,200,000 tons. It is this modern addition of at least fifty per cent. to the yield of sugar from the tropics which has brought down the price, to the prejudice of our West Indian planters and our Bristol refiners; and, instead of listening to protectionist arguments in favour of propping up class interests that are doomed, we should rather welcome the fact that a great industry has been established on the Continent, and one that, while especially benefiting our neighbours, is supplying us with cheap sugar, in obedience to the same law of international economics which enables us to provide ourselves with cheap bread and cheap meat.

It would be tedious to treat in detail of the minor food industries that are carried on in England, with more or less opposition from foreign rivals. If we include breweries, distilleries, and tobacco-manufactories among them, some are of considerable importance. Those last-named, however, are not likely to be much affected by the competition of other countries, while any injuries that may be done to the others are not of much general account. On the whole, indeed, we may look, not only with equanimity, but even with satisfaction, on the development of foreign food industries to the apparent, though in most cases only apparent, damage of our own. England has long since passed the stage of national life when it can sufficiently feed itself. Its prosperity during the past half century is due to the fact that, through the skilful use which its people have made of the mineral wealth ready at their hands, it is able to produce metallic, textile, and other goods in such abundance and variety, and of such quality, as to supply the wants of foreign countries, and to buy from those countries, with profit to itself, not only the raw materials for its manufactures, but also the food required to eke out its own resources. Whether our eminence in these respects can be permanently maintained, whether our country can continue to be the greatest factory and the greatest mart in the world, is a question that cannot be too carefully considered. Any real decline from our present high position would be ruin to us; and our difficulties would be not a little aggravated by the fact that our population is already far too numerous to be fed out of our own resources, and that the loss of the manufacturing and commercial advantages we now possess would mean the loss of means for obtaining enough even of the necessaries of life for all the inhabitants of the country. But, whatever risks we may be running, we cannot lessen them by endeavouring to dispense with our foreign food supplies. Every foreign rivalry that brings more and cheaper food to us, even if it injures particular classes and particular trades, and thus forces them into new lines of enterprise, is to the whole community a clear and important benefit. And the sooner this fact is generally recognised the better.

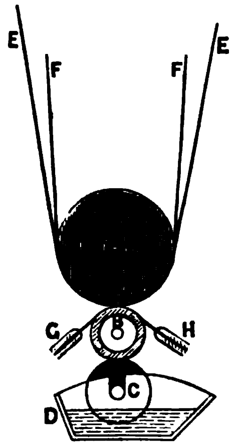
COTTON.—XXIII.

CALICO-PRINTING MACHINES—HOW BANDANA HANDKERCHIEFS ARE MADE.

BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

BELL'S machine, as we have seen, was the parent of cylinder printing. Its leading feature was the substitution of a roller, engraved so as to represent an endless block. It converted the slow and intermittent operations of the block printer into a rapid and continuous process. If we analyse a calico-printing machine, we shall find that its chief parts are an engraved roller bearing the design to be printed, a roller for supplying the engraved surface of this with colour, and a smooth-surfaced cylinder to press the cloth against the engraved roller and take off an impression. Auxiliary to these are a trough for the colour and two "doctors." In the accompanying figure we have these parts dissected out—A being the pressure cylinder; B the engraved roller, and C the colour or "furnishing roller" working in the colour trough D. On either side of the engraved roller the doctors are seen in section. That on the right hand (H), supposing the pressure roller to be moving in the direction indicated by the arrow, is the "colour doctor." It is a thin slip of steel or other hard and flexible metal, clasped between two bars, and made to press against the roller by means of levers and weights. Its function is to remove all colour from the roller except what the lines of the design have taken up. The other doctor (G) is similar in construction. It is called the "lint doctor," and its office is to remove from the roller any particles of fibre or dirt that it may have gathered off the cloth. Between the pressure roller and the calico being printed (E E) a "blanket" (F F) is run, which softens the impression, and keeps the colour which may be pressed through the calico from soiling the covering of the pressure roller.

In describing these several parts more minutely, the engraved roller claims precedence, as it is the most important feature of the machine. The roller consists of a cylinder of copper three or four inches in diameter, and of a length suitable to the cloth it is designed to print. When put on the machine it has an iron mandril passed through it, which serves as an axle. The surface of the roller is first turned "true," and is then passed to the engravers. In the early days of the cylinder machine the rollers were entirely engraved by hand, the engraver measuring off and drawing the design on the surface, and then cutting it out with the graver. This was a slow and expensive process, and restricted the multiplication of patterns. In the year 1808, Mr. Joseph Lockett, an engraver for calico printers at Manchester, adopted a plan whereby the rollers were engraved by mechanical means. He got his idea from Mr. Joseph Perkins, an American, who invented a mode of multiplying plates for printing bank-notes, which was found suitable for dealing with the rollers of the calico-printing machine. In Mr. Lockett's hands the invention was carried to perfection, and had an important influence on the trade. On examining a piece of printed calico or of wall paper, which is printed in the same way, it will be observed that the figuring is made up by the repetition in a longitudinal direction of a single group of forms and colours, varying according to the diameter of the engraved roller, from nine to eighteen inches, or so. The roller has to contain on its surface a complete unit of design which may be repeated continually without showing a break. From this it will be seen that exact measurement is necessary in adjusting the design to the roller.



ESSENTIAL PARTS OF CALICO-PRINTING MACHINE.

The system of engraving introduced by Mr. Lockett consists of an arrangement whereby the design is first engraved on a small steel roller, and thence transferred to the surface of the copper roller. The plan is suited only to small patterns such as are used in the finer classes of goods. The engraver takes a cylinder of steel, about three inches in length and one inch in diameter, and having softened it by a simple process, draws and engraves on it a complete unit or series of units of the design. He then covers the cylinder with chalk paste, and places it in a vessel containing bone ash, in which it is heated to a certain degree, and then suddenly cooled. This restores its temper, and fits it for the next operation. The design is, as in ordinary steel or copper engraving, cut into and

not raised upon the surface of the metal. As the object is to transfer from this small cylinder, or die, the pattern to the surface of the copper printing roller, it is necessary to provide an intermediary die on which the *intaglio* lines of the first shall appear raised. This second die is obtained by pressing the first against a cylinder of soft steel of similar dimensions. The pressure, which has to be considerable, is applied in a "clamming machine," in which the two cylinders are, while in contact, made to revolve. An examination of the soft cylinder, technically known as the "mill," will now show that its surface bears in relief a complete copy of the lines of the die first made. On being removed from the machine, the "mill" is hardened in the same way as the die was, and is now ready to operate upon the printing roller. The latter is mounted on a sort of lathe, and sections of its surface are successively brought into contact with the "mill," which is fitted to a slide-rest. The process may to the uninitiated seem rather a roundabout one, but its advantages are considerable. To show this, it is only necessary to state that the surface of the die is perhaps not more than a fortieth of the dimensions of the surface of the roller, so that the labour spent in producing the "mill" is amply compensated for, and another result is the securing of great uniformity in the lines of the pattern. Several variations of this mode of engraving have been tried with more or less success, according to the purpose in view. Sometimes the die is a flat steel plate from which the "mill" gets its impression by rolling, and at others the die is cylindrical, and the "mill" flat.

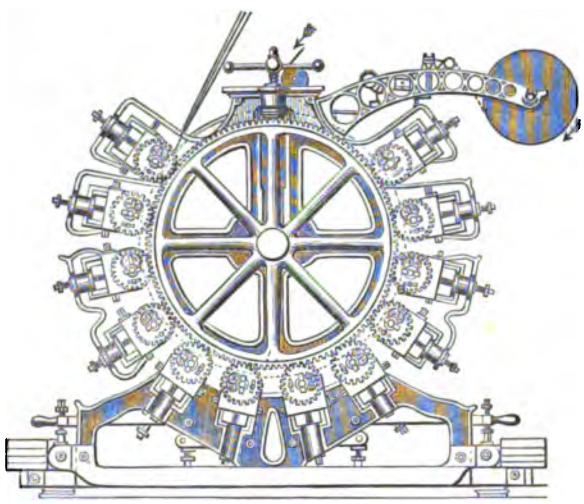
Etching is also employed in producing designs on the printing rollers. In this case the roller is coated with bituminous varnish, and the figures are either drawn by hand, or by means of a pentagraph. The application of the principle of the pentagraph to engraving rollers for calico printing was patented in 1834, by Mr. H. Deverill, of Manchester; but it was not brought into practice until some time afterwards. Mr. Lockett tried to introduce it, but did not quite succeed. The difficulty was to transfer a design from a flat drawing to the cylindrical surface of the roller. In 1848 Mr. Isaac Taylor patented a process which was successful, and became the first commercial use of pentagraph engraving in England. It was not, however, adopted to any great extent. Mr. William Rigby patented a pentagraph for calico-printers in 1854, and in 1857 effected improvements which led to the invention being used by a number of engravers. In this machine the design was engraved on a curved zinc plate, from which it was transferred to the surface of the roller by points. The roller was mounted in the upper part of a frame, and the zinc plate was fixed beneath in such a position that its curve formed the arc of a circle struck from the centre of the copper roller. Simultaneously with the appearance of the improved form of this machine, Mr. William Shields patented a pentagraph which transferred from a flat plate. This was an obvious advantage. Messrs. Lockett, Leake, and Co., of Manchester, adopted the machine, and in their hands it became a success, and is now in general use. From a single drawing of a flower or sprig it produces simultaneously on the surface of the roller as many exact copies as are required in the width of the cloth, and this effects an enormous saving of labour. Both this machine and one which produces work somewhat resembling that done by the rose-engine, are used for engraving "grounds" for the finer qualities of prints. When the scratching of the design on the varnish is completed, the rollers are immersed in diluted nitric acid, which attacks the parts laid bare by the diamond points, and eats its way into the metal to a depth sufficient for the purpose of printing. When this is accomplished, the roller is washed, the varnish is removed, and after the lines have been touched up in some parts with the graver, the roller is ready to work from.

For each colour that enters into a design a separate roller has to be engraved, and this has to be drawn so accurately that when the cloth is printed, every part of the device shall fall neatly into its place. The rollers, it will be understood, are an expensive part of the calico-printer's plant. The work of the engraver goes on continuously, for the demand for fresh patterns knows no limits. When a pattern goes out of fashion the rollers used in printing it are turned down to a fresh surface, and again placed at the disposal of the engraver. A great improvement has taken place in recent years in the designs produced by English calico-printers, and a little less slavish reliance on French genius is being manifested; but still there is not that encouragement given to native talent that one would like to see. Of the so-called "designers to calico-printers," employed in Lancashire and elsewhere, not a few find their chief occupation in "adapting from the French," and other sorts of cobbling. When the trade was in its infancy in this country, the designers, or "pattern-drawers," as they were called, were regarded, or regarded

themselves, as personages of some importance. "The pattern-drawers," we are told, "appeared in white silk stockings, silver buckles on the shoes and at the knee, ruffles at the wrists, soft cravats of fine muslin tied round the throat, with long ends falling on the breast, and often embroidered; and the hair powdered."

Of the colours used by calico-printers, we shall have to speak further on. Our present business is to describe the printing machine. The colour is supplied to the engraved roller by the furnishing roller (C, in woodcut on p. 111). The latter consists of a wood or metallic core, having a covering of several folds of stout calico. It is mounted over the colour-trough, so that one portion of its circumference is always immersed in the colour. As it revolves it carries with it a load of the latter, which it deposits as a thick coating on the engraved roller. This free supply is necessary in order to ensure that all the lines of the engraving shall be filled. The superfluous colour is removed by the "doctor," or scraper already mentioned. The blade of the "doctor" must fit exactly parallel to the roller, so that every particle of colour may be scraped off, except what is held by the engraved lines. Screws are provided whereby this exact adjustment may be secured, and the weighted levers admit of any amount of pressure being applied. It will be observed that the colour-trough widens out to one side: that is to enable the printer to pour in fresh supplies of colour, without inconvenience.

The pressure roller, A, is of iron, and in order to give it an elastic surface it is covered with woollen cloth to the thickness of half an inch. The blanket, F F, is usually about forty yards in length. It is interposed between the pressure roller and the calico, in order to keep the latter clean. It is an endless belt, and travels over rollers conveniently placed. One of these rollers is in a hot air chamber, so that the blanket is undergoing a continuous drying process which removes the moisture imparted by the cloth and the colours.



END VIEW OF A TWELVE-COLOUR CALICO-PRINTING MACHINE.

In the earlier machines the blanket was made of very thick, but even, woollen cloth, made specially for the purpose. In 1855 Messrs. Macintosh and Co., of Manchester, patented a new kind of blanket made by cementing together with india-rubber several folds of stout calico. This was found to answer admirably, and as it was cheaper than the woollen blanket, it at once recommended itself to the printers, and is now in general use. Some printers run a piece of grey cloth between the blanket and the calico being printed, and this arrangement is said to give a sharper impression.

From two to six colours are the common numbers used, but machines have been made for printing as many as twenty colours. The figure on this page gives an end view of a twelve-colour machine which will show how the printing rollers and their appurtenances are arranged round the central pressure cylinder. Each printing cylinder has its colour trough and doctors, and is mounted in a jaw on the frame of the machine. Its bearings slide in a groove or slit, and it can be moved to or from the pressure roller by means of screws at either end. This facilitates cleaning and changing, and admits of any number of the rollers being left out of a design, so that the machine shown here could be used to print two, or any other number of colours, up to twelve. It will be observed that the machine is very compact. The calico to be printed is supplied from a roll mounted on projecting arms at the rear of the machine. In order that it may print nicely it has already been damped, either by exposure in moist air, or by being passed through a damping machine, in which a fine spray of water was thrown upon it. Each roll contains forty pieces of cloth, either stitched or gummed together. The cloth is wound on the roller by a machine called a candroy, which stretches it laterally, and lays it smoothly on the roller. In its passage from the roller to the first printing cylinder it is further stretched and smoothed by being led between rectangular rods, and over a "scrimping-bar." The latter is a slab of wood or metal, the upper surface

of which is grooved diagonally, right and left, from the centre.

If the eye could follow the cloth through the machine, it would observe how each roller contributes its quota to the complete design. This one putting in a stem, that a spray, another a leaf, and so on. Sometimes the cloth is fully printed in the machine, and comes forth with its colours quite radiant, but in other cases it presents a very uninteresting appearance, and its beauties are not revealed until it has been "dyed up." How this comes about we shall see later on. In the meantime, the cloth, no matter in what style it be printed, on leaving the machine, is led away into a hot air chamber, and dried thoroughly.

Bandana handkerchiefs, which used to be imported from India in considerable quantities in the end of last and beginning of the present century, and were an essential part of the equipment of the man of fashion, were long a puzzle to the printers and dyers of this country. They were of silk and bore white spots on a uniformly dyed red ground. The spots were produced by tying up the cloth at those parts so tightly that when the handkerchief was dipped into the dye the latter could not penetrate the protected parts. When the cloth was dyed and the tyings loosed the white spots revealed themselves. Many attempts were made in this country to imitate the product of Indian industry, but with little success until about the year 1811, when M. Kœchlin invented the "discharge process" of figuring dyed cloth. This beautiful discovery was at once adopted by Messrs. Monteith and Co., of Glasgow, and so successfully worked as to produce goods exceeding in beauty the famous bandanas of India. Several other Glasgow firms turned their attention to the production of bandanas, and the city and its neighbourhood has since enjoyed almost a monopoly of this branch of manufacture.

The cloth intended for bandanas is dyed of a uniform colour—most commonly red or blue—and a dozen pieces are laid one over another and wound upon a roller. This roller is placed on bearings behind a press of peculiar construction. The press consists of a bed-plate mounted on hydraulic gear and an upper plate or "platen." The printing, if we may so call it, is done by means of two stout plates of lead fixed to the upper and lower plates of the press respectively. If the design is to consist of, say, white spots on the coloured ground, the exposed surfaces of the lead plates have cut into them a series of depressions corresponding to the size and number of the spots desired. These have to be accurately placed, so that when the two plates are brought together the depressions in the one shall fall exactly over those in the other. All being ready, the pressman takes hold of the end of the twelve-fold web of cloth and lays it on the lower plate. The plates are then brought together with a pressure of two or three hundred tons. It will be noted that now the whole body of the cloth is tightly pinched except those parts which come between the depressions in the plates. Communicating with each of these depressions are openings through the upper plate, and channels leading thereto. When the pressure is fully on, a tap is opened and a stream of bleaching liquid flows along the channels in the upper plate and finds its way by the apertures to the cloth, through which it passes and makes its exit by openings in the depressions in the lower plate. To quicken the action of the liquid and cause it to penetrate the exposed parts of the cloth thoroughly, a force-pump is employed. As the liquid passes through the cloth it dissolves the connection between the mordant and the colouring matter, and carries off the latter, leaving the parts it has come into contact with purely white.

A press attended by one man is capable of producing 700 handkerchiefs per day. There is no limit to the variety of forms that may be given to the cleared spaces, and many beautiful effects are produced by printing various colours into these. The effect of the adoption of this process of producing bandanas was (it need scarcely be said) to reduce their cost enormously, and consequently bring them into greatly extended use.

COTTON.—XXIV.

CALICO PRINTING (*continued*)—STYLES OF PRINTING—THE MADDER STYLE EXPLAINED—HOW MORDANTS AND COLOURS ARE PREPARED—PIGMENT PRINTING—STEAMING—CALENDERING, ETC.

BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

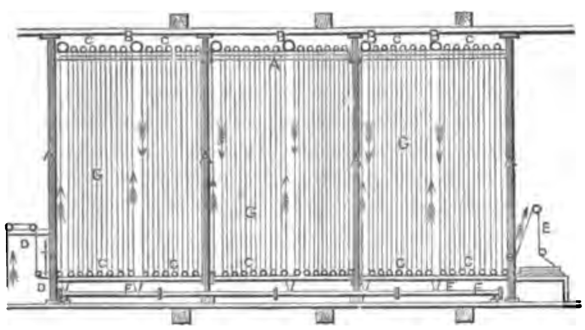
THE styles of calico printing are so numerous, and the processes so varied, that a bare enumeration of them would occupy several pages of this work. They may, however, be grouped under the five following classes:—1, The fast colour or chintz style, in which the mordants are applied to the white cloth, and the colours of the design are afterwards developed in the dye-bath; 2, Where the whole surface receives a uniform tint from one colouring matter, and figures of other colours are afterwards brought up by chemical discharges and reactions; 3, Where the white surface is impressed with figures in a resist paste and is afterwards subjected to a general dye; 4, Steam-colours, in which a mixture of the mordants and dye-extracts is applied to the cloth, and the chemical combination is effected by the agency of steam; 5, Spirit-colours, consisting of mixtures of dye-extracts with nitro-muriate of tin.

Strange as it may appear, it is nevertheless a fact that the manner in which the colouring principle of dyes, &c., becomes incorporated with the fibres of cotton remains unexplained to this day, though many chemists and microscopists have endeavoured to discover it. The earliest investigations of which we have any record appear to have led to the conclusion that the connection between the fibre and the dye was a purely mechanical one—that the mordant entering the pores of the fibre and crystallising therein, opened them up for the reception of the dye, to which the crystals gave place on being dissolved in the vat. About the middle of last century the result of further research on the subject was accepted as conclusive proof of the fallacy of the mechanical theory, and as establishing that dyeing was a chemical process—that the matter of the fibre entered into chemical combination with the dye-stuff, changing it from a soluble to an insoluble substance, and showing therein a power of chemical affinity. For a century this explanation was allowed to pass unchallenged. In the year 1840, M. Dumas, a French chemist, and Mr. Walter Crum, of Thornliebank, who had been making independent investigations, announced an opinion at variance with the chemical theory. The latter gentleman held that it was either owing to surface contact of the dye-stuff with the cotton or to its entering into the pores or the central opening of the fibres. The power which the cotton fibre possesses of appropriating oxides from solutions, as well as colouring matters such as indigo, was viewed by Mr. Crum as simply a case of surface attraction. Other views have been subsequently advanced on the subject; but, as already stated, we are still without any generally acceptable theory on the relation established between cotton fibres and colouring substances in the process of dyeing.

It would be tedious to go into detail on the colouring matters used by the calico-printer and the modes of applying them. One or two illustrations will suffice to show that the art is one which affords much scope to a man of genius, and that it is from first to last a beautiful result of chemical research and application. Let us take a piece of cloth printed in the madder style, and bearing a design in black, red, purple, and white, and see how the colours were produced. For each colour a roller had to be engraved bearing its respective part of the device, and the printing was done at one operation in a four-colour machine. When the cloth left the machine it bore nothing approaching its present appearance. Its entire surface was covered with paste of various hues, but no decided colour, and on close examination some indication of a design could be discovered in the paste. This is explained by the fact that what were printed in the cloth were not the actual colours, but mordants, which would in the dye-vats combine with the colouring principle of the madder and produce the desired result. The portions of the design intended to be black were printed with a mordant composed of a strong solution of iron, for the purple a weak solution of iron was used, for the red acetate of alumina, and for the white a "resist" composed of citric acid. The difference between a mordant and a resist is that while the former attracts the colouring matter and makes it yield a certain shade, the latter prevents the dye from affecting the cloth in any way.

After passing through the printing machine the cloth had to undergo various processes before it was ready to be dyed. To begin with, it was thoroughly dried by being exposed to currents of

hot air in a specially devised chamber. It was then "aged"—that is, exposed to the atmosphere under conditions favourable for the mordants, &c., attaching themselves firmly to the fibres and absorbing oxygen. The "ageing" rooms of a print-work are large apartments fitted with rails on which the cloth is hung in open folds. They are well ventilated, and the temperature is maintained at summer heat. The time of exposure is determined by the nature of the mordants, and varies from one to six days. As the success of the subsequent operations depends on the "ageing," great care is taken to have it properly carried out. The "ageing" rooms are being superseded by a machine which greatly expedites the operation. This consists of a close chamber, near the roof and floor of which are mounted in close order a series of tin rollers, long enough to accommodate two pieces of cloth side by side. The cloth is led over these rollers as shown in the accompanying woodcut. At intervals larger rollers are placed, which open up a space between the folds of cloth. At the bottom of each such space is a funnel communicating with steam-pipes. The cloth is drawn slowly through the apparatus, the time occupied by any part of it in passing being twenty minutes. The air in the chamber is kept slightly moist by the admission of steam through the funnels. What takes place in the process of "ageing" has not been investigated fully, but its importance is patent to every printer. One authority considers it probable "that as the piece leaves the printing machine the mordant is almost altogether on the surface of the fibre in an unaltered state, the thorough permeation of the piece by the aqueous vapour dissolved in the air restores to the cloth the normal moisture removed by the drying in the hot room, and that under the influence of this and the slightly elevated temperature, first the separation of the mordant from the thickening substance takes place, and the solution is diffused through the fibre; and, secondly, that the fibre now begins to play the part of an acid of superior affinity for the base of the mordant to the volatile acetic solvent, and gradually withdraws it from the mordant, acetic acid being freely given off, as is evident enough to the eyes and nose on going inside the machine."



AGEING MACHINE.

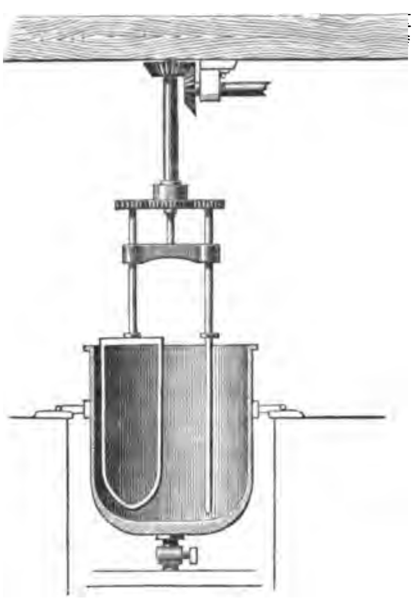
(A) Framework of Machine; (B) Large Tin Rollers; (C) Small ditto; (D) Point at which the Cloth enters the Machine; (E) Point of exit; (F) Steam-pipe with Funnels opening into the wide spaces formed by the Rollers (B.); (G) the Cloth passing through the Machine, its direction being indicated by Arrows.

"Dunging" is another important process to which the cloth is subjected prior to dyeing. It follows the "ageing," and its purpose is to remove or render innocuous any uncombined mordant that may remain on the surface of the cloth, to neutralise the acids, and to remove the thickening agents used. From time immemorial the dyers of the East have used a liquor of which cow-dung is the principal ingredient, and in borrowing their art the dyers of this country used the same materials. Substitutes for the dung have been found, and are now extensively used. The principal of these are the silicate and the arseniate of soda. But, no matter what is used, the process retains its ancient though rather inelegant name of "dunging." Much of the beauty of the colours and the sharpness of the figures depends on the process being conducted in a perfect manner. Any redundancy of mordant would cause blurs in the dyeing, and any loose particles would seriously mar the work. The cloth is twice dunged, the first time in a cistern with rollers, care being taken that every inch of the surface shall come into direct contact with the liquor, and the second time in a beck with a revolving drum. The cloth is washed in clear water after each dunging.

Having gone through the processes described, the piece of cloth we have in view was ready for dyeing. To the uninitiated it would seem that the work of the printer must now have been thoroughly obliterated; and truly the cloth at this stage exhibited little trace of the beautiful device engraved on the rollers with which it was printed. A dip in the dye vat, and a subsequent "clearing" showed, however, that the printer had not toiled in vain, and that the careful treatment through all the processes had resulted in the production of a perfect piece of goods. Dyeing in this style seems a work of magic. When the cloth enters the vat or beck of dark-red liquor it shows nothing but what appear to be slight stains; but when it comes forth it bears the device completely evolved in black, purple, red and white. All that remains

to be done is to "clear" the cloth by a thorough washing in a hot solution of soap, and subsequently in pure cold water. This removes the superfluous dye and leaves the colours bright and the white pure. When dried and dressed the cloth is ready for the market.

An important department of the printer's work is the preparation of the mordants and dye-extracts for printing. All have to be made up into pastes of the consistency of molasses, and this is done by incorporating with them some innocuous substance. If the mordants or colours were used in a very fluid state they would spread on the cloth and it would be impossible to produce a design with them. They would also penetrate through the cloth, whereas, for various reasons, it is desirable that only one side should be affected by the printing or dyeing. The colour room is a distinct department of a print-work, and where a large variety of work is done the stocking of it is a costly business. The chemicals and dyes are received in a condition ready for mixing or thickening. Along one side of the room is a range of copper vessels of various sizes, and it is in these that the pastes are prepared. The colour pan has a double bottom for the admission of steam, and is so mounted that it may be tilted over when the paste is to be removed. Inside the pan are a pair of revolving stirrers which are operated by a connection with a shaft overhead. Formerly the stirring was done by hand with a broad, flat paddle. The formation of the pan and its mounting are shown in section in the above figure. A variety of thickening substances are used, but the more common are the following:—wheat flour, wheat starch, British and other gums, torrified potato farina, pipe and china clay, sulphate of lead, dextrin, albumen of eggs, gluten and glue. The substance used depends on the nature of the colour or of the mordant, and it is most important to avoid chemical combination between the two. A strong acid mordant cannot well be thickened with starch, but it can be with gum. The same mordant when thickened to different degrees gives different results in dyeing. There are many other points which the colour preparer has to consider in order to ensure satisfactory results. When the paste has been brought to the required condition, cold water is run into the double bottom of the pan for the purpose of cooling the stuff and making it more quickly ready for use. When the paste is drawn off, it is strained to free it from any grit that would act injuriously on the printing rollers. There are several varieties of straining machines in use, but the principle of all is the same—namely, a cylinder fitted with a straining cloth or sieve, and a plunger which presses the paste through the pores of the latter.



SECTION OF COLOUR PAN, SHOWING DOUBLE BOTTOM AND STIRRING APPARATUS.

Fixing colours by the aid of steam is a style which has been largely developed since the introduction of aniline colours. The process is so simple and expeditious that it is fast driving others out of use. "There is no limit to the number and variety of shades that may be produced, each colour box in the cylinder printing machine containing the whole ingredients essential to the production and fixation of a separate and distinct shade or colour." In preparing the cloth for being printed with steam colours, it is first mordanted by being run through a solution of stannate of soda, then through a weak solution of sulphuric acid, and finally washed and dried. The sulphuric acid decomposes the stannate and precipitates the stannic acid (peroxide of tin) on the cloth. The materials most commonly used in steam-printing are logwood liquor, annatto, Persian berry liquor, prussiate of potash, cochineal, madder extract, alizarin, Prussian blue and Japan wood liquor. The paste for printing dark blue for steaming is prepared as follows:—7 gallons water, 14 lbs. starch, 2¾ lbs. sal-ammoniac; boil, and add whilst hot, 12 lbs. yellow prussiate of potash in powder, 6 lbs. red prussiate of potash, 6 lbs. tartaric acid, and, when nearly cold, 1 lb. sulphuric acid, 1 lb. oxalic acid dissolved in 2 quarts of hot water, and 6 gallons prussiate-of-tin pulp. Under the action of the steam these ingredients set up chemical action which results in imparting to the cloth the desired colour.

When printing with pigments to be fixed by

steam—a style of work yet in use to some extent—was introduced, great difficulty was experienced in finding a suitable material for fixing the colour to the cloth. A solution of india-rubber in naphtha was tried with success. It was easily worked, and when the naphtha was driven off by the steam the colour remained securely attached to the cloth. The volatilisation of the naphtha, however, led to serious explosions; and the use of that agent was given up. A trial was next made with albumen and some kindred substances, and with good effect. The principal fixing materials now used for pigments are albumen of eggs, blood albumen or dried serum of blood, lactine, and gluten. It will be understood that according to this mode of printing only a mechanical connection between the cloth and the colour is established. The connection is, however, a close one, and the colours stand soap and friction well.

By whatever method the cloth intended for steaming may have been printed, it is, after leaving the machine, hung up for a little time, in order to equalise its temperature. There are several modes of subjecting the cloth to the action of the steam. The oldest and most common of these is that known as the "column." The column is a hollow cylinder of copper, three or four inches in diameter, and a little over three feet in length, and it is perforated all over with minute holes, a quarter of an inch apart. In using the column a few folds of blanketing are first wound round it, and over that the printed calico, with a piece of plain cloth inserted to prevent the colours from being transferred. An envelope of calico is wrapped over all, and then the column with its charge has one of its ends fixed in an aperture in a steam-pipe, so that it stands in a perpendicular position. On a tap being turned, steam rushes into the column, and through the perforations into the cloth. In from twenty to thirty minutes, according to the nature of the colours, the operation is complete. The cloth is unwound from the column at once, in order to guard against injurious condensation, which would be fatal at that stage. Within a minute of being removed from the column the cloth appears perfectly dry.

The column system of steaming has been superseded to a large extent by the chest, or cottage, arrangement. For this an iron chamber ten feet in length, and eight feet in height is used. The chamber is built in a somewhat cylindrical form, to give it strength to resist the pressure of the steam. In the bottom of it, rails are fixed for the wheels of a carriage, or frame containing the cloth. Beneath the rails is a perforated flooring, and under that is a steam-pipe pierced with numerous small holes. The door is steam-tight, and a safety-valve is provided, to prevent the pressure getting beyond a certain point. The cloth is prepared for steaming by being wound upon a reel, from which it is removed and hung upon rods arranged in the upper part of a frame mounted on wheels. When all the rods are filled, the frame is run into the chamber on the rails already referred to, the door is fastened, and steam is allowed to flow in. The time of exposure varies according to circumstances, but usually forty-five minutes are sufficient. Each chamber is provided with two frames, so that while one is inside, the other is being filled. An improvement on this system was patented in 1874 by Mr. W. Mather, of Manchester, and M. Cordillot, of Moscow. In this case, the chamber may be constructed of iron or brickwork. In the upper part of it, and mounted transversely, are a series of cylinders. The perforated floor is furnished with rails, and a steam-pipe similar to that in the apparatus previously described. When in use the rails are occupied by six wagons made of wire. The cloth is fed in a continuous length between rollers in the upper part of the chamber. Passing from cylinder to cylinder, it is made to traverse the chamber several times, being thus freely exposed to the steam. As it leaves the cylinders, it is deposited in loose folds in the last but one of the train of wagons. When that wagon is full, a door in one end of the chamber is opened, and the foremost wagon is drawn out. At the other end of the chamber a fresh wagon is run in, and all the others moved one place forward. The object of this arrangement is to allow the cloth in the first-filled wagons to be exposed to the steam for a sufficient time. In order to prevent condensation, the wagons are heated to a certain degree before being put into the chamber. The process, it will be observed, is a continuous one, and effects a considerable saving of labour and time. The chamber is capable of steaming a thousand pieces of cloth per day.

After being steamed, the cloth is washed to remove the paste and superfluous colour. It then receives a bath of weak solution of bichromate of potash, which, while not so strong as to affect the colours, is sufficient to clear the white. Washing in pure water follows, and after being dried in the hydro-extractor, the cloth is ready for starching. The latter operation is performed by a machine

with a set of cylinders, one of which dips into a trough filled with starch, and taking up an even coating, transfers it to the cloth, which is pressed against it. The cloth is dried by passing over steam-heated copper drums. The continuous longitudinal strain to which the cloth is subjected in being drawn through the various machines, has the effect of reducing its width considerably, and it is necessary at one of the final stages of its progress to "breadthen" it. This is done by exposing it to the action of a metal cylinder, the surface of which is cut into diagonal grooves starting from the centre. The grooves rub out the cloth in the direction of its breadth, in the same way as is done by the scrimping bar of the printing machine.

Calendering and folding complete the long series of operations to which the cloth is subjected from the time it leaves the loom till it is ready for the draper's counter. There are several kinds of "finish" given to calico goods, according to the purposes for which they are intended, and these are produced by putting the cloth through the calender in various ways. The calender commonly in use consists of from four to six cylinders mounted one over another in a strong frame. One of the central rollers is made of iron or copper, and has its interior hollow for the admission of steam. The rollers in contact with this above and below are made of paper compressed upon a spindle, and turned to an even surface. Paper is used on account of its being more elastic than iron, while it is not liable to warp like wood. The other rollers are of cast-iron. The pressure is regulated by means of screws pressing on the bearings of the rollers. Before the cloth enters the calender it passes over a revolving brush, which throws upon it a fine spray of water, and temporarily softens the starch. If it be desired to glaze the "face" of the cloth, as in chintz, the rollers between which it passes are made to move at different velocities, with the effect of rubbing the printed side of the cloth against the surface of the heated roller. The Indian calico printer glazes his work by rubbing it with a smooth stone. As the cloth comes through the calender, it is wound upon a beam, and on that transferred to the measuring and folding machine. There are several varieties of this machine in use, but the principle of action is the same in all. The cloth is drawn from the roller by an arrangement of levers or arms, and laid in folds of equal length upon a table. The length of the folds is determined by adjusting the traverse of the arms, and the record of length is kept by a counter and dial fixed to the apparatus. A doubling or two by hand reduces each bundle to the required dimensions, and it is then wrapped in paper, and carried to the warehouse.

Mention was made in a previous chapter of the manner in which madder was being superseded by the aniline colours. The following figures showing the falling off in our imports of madder, madder root, and garancine, between the years 1872 and 1878, bear remarkable testimony to the fact:—

	1872.	1878.
Madder . . .	271,931 cwt.	10,825 cwt.
Madder root . .	372,563 „	24,039 „
Garancine . . .	285,926 „	8,461 „
Total . . .	930,420 „	43,325 „

SHIP BUILDING.—XXIV.

THE PROGRESS OF OCEAN STEAM NAVIGATION.

COMPETITION so long continued and severe as that which has taken place for the possession of the valuable traffic across the Atlantic, could not fail to result in improvements to both American and British ships. Before the advent of steam-ships, the clipper sailing ships, originated in America, had been successfully imitated and improved upon in this country. And after the *Great Western* was regularly engaged on the service between England and New York, owners of clipper sailing ships, as well as many persons who had made passages in those vessels, were hopeful that they would be able to compete successfully with steamers. When these hopes proved futile, an endeavour was made to introduce auxiliary steam power into clipper sailing ships, so that they might be able to proceed during calms or against head-winds; lifting their propellers and "making sail" when the wind was favourable. But none of these attempts proved successful, and the full-powered steam-ship, with auxiliary sail spread, which originated in England, was finally accepted by the Americans. In 1850 the first attempts were made by our rivals to recover the ground lost

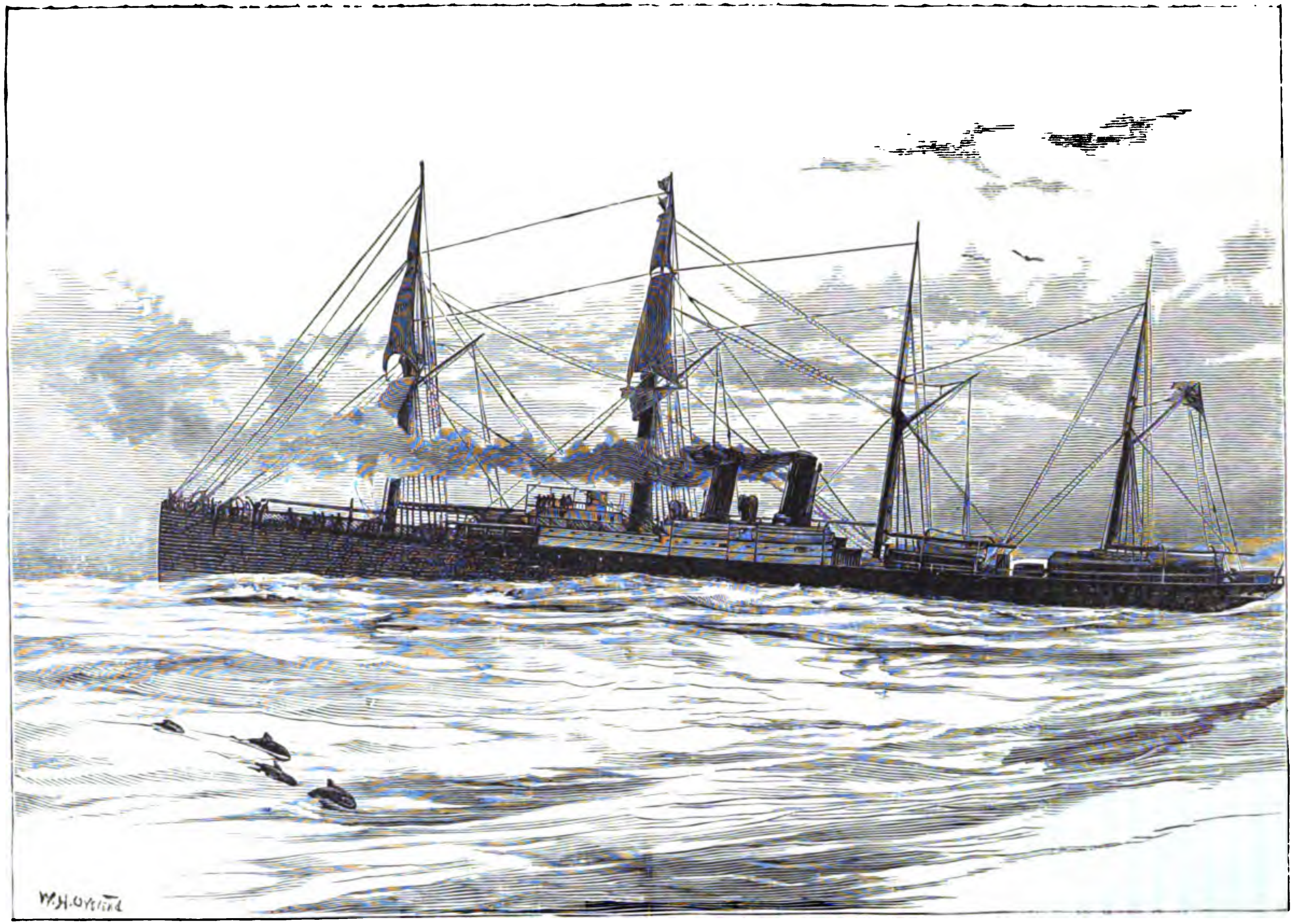
during the nine or ten years that British steamers had been successfully at work on the Atlantic service. The story of the "Collins Line" is too long to tell here; but its ending in disaster and great loss of life is still fresh in the memory of many persons now living. After this failure, Americans were content for many years to leave the mail and passenger traffic across the Atlantic almost exclusively to British steamers. But within the last nine or ten years they have again ventured into competition, and so far with some success. At present the number of British ocean-going steamers far surpasses that of steamers carrying the American flag. In fact, American skill and enterprise have been chiefly displayed in the development of steam navigation on their coasts and inland waters, and for ocean steamers the Americans have been content to imitate English models.

Resuming the narrative commenced in the last chapter, it must be noted that before the year 1838 ended several English steamers were running between Liverpool and New York. The comparatively high speed and regularity with which the passages of the *Great Western* were made, caused the Admiralty to call for tenders for the conveyance of the North American mails by steamers in October, 1838. This contract was secured by the now famous Cunard Company, whose pioneer steamer, the *Britannia*, started in July, 1840. From that time onward, the Cunard Company has achieved uninterrupted success, although it has had, and still has, to endure the stress of severe competition. About the same period (1839–40) the foundation of another of our great steam-ship companies was laid—the Peninsular and Oriental Company being entrusted with the conveyance of the Indian mails from England to Alexandria; and a few years later with the mail service between Suez and Calcutta. Almost simultaneously the Royal Mail Steam Packet Company began its service between England and the West Indies; while the Pacific Mail Company commenced its operations on the coasts of the South American continent. The vessels originally employed on all these lines were wood-built and propelled by paddle-wheels. Judged by present standards, they were small, slow, and expensive in working; but in their day they did good service, and demonstrated the practicability of ocean steam navigation in the most unmistakable manner. Still it must be recognised that subsequent progress would not have been possible had not iron superseded wood for the hulls, paddle-wheels given way to screw propellers, and improved types of marine engines been devised, by means of which large economies of fuel were rendered practicable.

The construction of the *Great Britain* in 1843 was an indication of coming changes, and the foresight of Mr. I. K. Brunel and others interested in the design of that vessel cannot be too highly commended, notwithstanding the unfortunate circumstances which led to her subsequent withdrawal from the trans-Atlantic service. In the first volume of this work, at p. 146, will be found an account of this notable vessel. It will suffice to say here that she was built of iron, of dimensions greatly exceeding those of any previous steam-ship, and that she had a screw propeller.

The Company which built and owned the *Great Western* and *Great Britain*, whose enterprise did so much to assure the extension of steam navigation, did not achieve the financial success they merited. After the *Great Britain* was wrecked, and the Cunard Company had secured the mail contract to America, both the ships were sold. The *Great Western* was bought for the West India mail service, and was finally broken up in 1857. The *Great Britain*, as already stated, was repaired, and for many years was successfully employed in the Australian trade. Furthermore, it is worth notice that the attempt to make Bristol the port of departure and arrival for the trans-Atlantic steamers signally failed, Liverpool soon obtaining the pre-eminent position which it still maintains. Bristol, which took the lead in building ocean-going steamers, has hitherto reaped no great reward. It falls below not merely London and Liverpool, but Southampton, Glasgow, and several other British ports which it formerly surpassed. Whether the dock extensions may help to retrieve its position it is difficult to say; but the honour of having produced the *Great Western* and the *Great Britain* will always remain to Bristol.

It would be idle to attempt even a sketch of the progressive extensions of steam navigation which have taken place in the half-century that has elapsed since the *Great Western* made her maiden voyage. Limits of space prevent more than a hasty glance at some of the salient points in this interesting history. Speaking generally, it may be said that the earlier attempts at long over-sea voyages in steam-ships were made by subsidised lines of steamers, which carried the mails, and depended largely for their commercial success upon passenger traffic, or the conveyance of higher class goods requiring quick delivery. The British Admiralty formerly arranged these mail contracts; laid down



THE ORIENT STEAM NAVIGATION COMPANY'S STEAM-SHIP "ORIENT."

the conditions of speed, structural strength, &c., and appointed inspecting officers to see that these conditions were fulfilled. Further, all the mail steamers were built in such a fashion that they could be armed in case of war, and made auxiliaries to the ships of the Royal Navy. This latter condition has been abandoned for nearly a quarter of a century, and the mail contracts are made simply on the basis of the conveyance of the mails in certain definite times, and with proper precautions for their safety. Every one who has considered the subject, agrees, however, that these magnificent steamers ought to be made capable, not merely of self defence against "Alabamas of the future," but of acting as protectors to our vast mercantile marine. In their speed at sea, and power of rapidly traversing immense distances, merchant steamers of the first class are much superior to war-ships, and England is pre-eminently rich in such vessels. There has of late been a disposition to revive, in some fashion, the old arrangement, which made mail steamers an important element in the national defence; but nothing appears to have been definitely settled, nor is it easy to arrange a satisfactory plan, by which, without interfering with their ordinary work in time of peace, merchantmen may be made rapidly available for warlike services. The matter is one deserving of the most serious consideration, and demanding a speedy settlement.

Subsidised mail and passenger lines of steamers by no means include all the finest and swiftest ships. On the contrary, private enterprise has originated and maintained some of the most successful lines, traversing the longest distances. There has been frequent agitation, in consequence, for the abolition of subsidised lines conveying the mails. The proposal which finds favour as an alternative for the present system, is to treat mails similarly to merchandise, giving to every well-appointed steamer of a certain speed the right of conveying mails at certain fixed rates, guarantees for safe conveyance being given. We express no opinion on these rival schemes; but the tendency seems to be in favour of the decrease, if not the abolition, of subsidies for the mail service.

A third group of merchant steamers, and by far the most numerous, is that specially designed for cargo carrying, in which the accommodation for passengers is either limited or altogether wanting. These are the vessels which are gradually pushing their way into more and more distant regions, and successfully competing with sailing ships. Sailing ships are still at work in much greater numbers than steamers, and will long remain so; but while the steamers are continuously increasing in numbers, the sailing ships have been almost at a standstill for several years. In 1874 the United Kingdom possessed 12,934 sailing ships "of and above 50 tons," and 2,845 steamers. In 1878 there were 12,580 sailing ships and 3,410 steamers. These figures do not represent the full gain of the steamers, to apprehend which the tonnage must be added. In 1874 the sailing ships of and above 50 tons had an aggregate tonnage of 3,793,000 tons; and in 1878 the corresponding aggregate tonnage was 3,924,000, an increase of about three and a half per cent. only in five years. For the steamers the corresponding aggregate tonnage was 1,842,000 tons in 1874, and 2,282,000 in 1878, an increase of about twenty-four per cent. in five years. Taking the vessels engaged in the "foreign trade," it appears that in 1874 there were 5,613 sailing ships, having an aggregate of nearly 3,100,000 tons, and manned by 82,700 men and boys; whereas in 1878 there were 5,235 sailing ships of nearly three and a quarter million tons, manned by less than 79,000 men and boys. Of steamers engaged in the same trade there were, in 1874, 1,597 ships of one and a half million tons, manned by 57,800 men and boys; while in 1878 there were 1,820 ships, of over 1,800,000 tons, with crews exceeding 57,100 men and boys. Here also the steamers are evidently gaining on the sailing ships. Another notable fact is the much greater average size of the steamers. Taking the foregoing figures, it appears that the average tonnage of the sailing ships engaged in the foreign trade in 1878 was less than 620 tons, whereas for the steamers the corresponding average was 1,000 tons. It will be remembered that for the steamers the registered tonnage allows a deduction for engine space, &c.;* so that it is within the truth to say that the average merchant steamer engaged in the foreign trade is of twice as great tonnage as the average sailing ship.

To the general reader it may appear singular that steamers can compete successfully with sailing ships as cargo-carriers, seeing that in first cost and in working expenses the sailing ship has so great an advantage. But the fact is undoubted, and before the Suez Canal was opened, steamers were running to China *viâ* the Cape of Good Hope. One of the most successful of these lines was started in 1865 by Messrs. Holt of Liverpool, and covered a steaming distance of over 13,000 miles, the average speed for the whole distance sometimes

* Vol. III., p. 24.

reaching nine and a half to ten knots. The late Mr. Lindsay in describing the performances of these vessels says:—"Starting from Liverpool they never stopped till they reached Mauritius, a distance of 8,500 miles, being under steam the whole way. . . . Thence they proceeded to Penang, Singapore, Hong Kong, and Shanghai, and though unaided by any Government grants, they performed these distant voyages with extraordinary regularity." Hereafter, we shall describe the improvements which have rendered such performances possible within thirty years of the time when it was gravely debated whether a voyage of 3,000 miles was practicable for a steamer.

The opening of the Suez Canal has given a great impetus to steam navigation, especially as regards the traffic with India and China. The saving in the distance to India is enormous; that to China is less considerable, but still worth making. From Plymouth to Bombay, *viâ* the Cape of Good Hope, is nearly 10,500 nautical miles; *viâ* the Suez Canal the distance is only 6,000 miles. Sailing ships, under the most favourable conditions, occupy about three and a half to four months as an average time on the voyage home from Bombay; and Lord Macaulay spent nearly six months, it will be remembered, on his homeward voyage from India. Steamers now frequently make the passage in less than thirty days, under ordinary conditions, carrying cargo as well as passengers; whilst the swifter vessels can average twelve knots for the whole distance, except the interval occupied in passing through the Suez Canal. The extent of the steam communication between Great Britain and India will be evident to any one who will take the trouble to glance down the shipping notices in the daily newspapers; and not merely in the direct trade with India are steamers gaining rapidly upon sailing ships, but the same thing is true of all parts of the Indian Ocean and Persian Gulf. Frequent and regular sailings take place of steam-ships adapted for cargo and passenger traffic; and the voyager has no difficulty except that arising from the extensive choice afforded him by competing lines. The vast extent of the operations of some of these companies may be illustrated by one example. The British India Company have steamers running from London *viâ* the Suez Canal to Kurrachee, Bombay, Madras, Calcutta, and other principal ports on the coast of India, Ceylon, and Burmah; while other steamers trade to the Persian Gulf, and down the east coast of Africa to Zanzibar; and many branch lines are worked in association with the main lines of communication. In 1876 this enterprising company alone owned over forty iron screw steamers, employed on thirteen different lines, and it was estimated that the distance annually traversed by these vessels exceeded one million miles. No other company engaged in the same trade can compare in magnitude with the British India Company, but there are others which own a large number of very fine vessels, which perform their voyages of eight or nine thousand miles with regularity and despatch.

The passage to China has been shortened from about 13,500 miles to about 9,800 miles by the opening of the Suez Canal, and steamers engaged in the China trade no longer go round the Cape of Good Hope. Greater speed has been given to the vessels recently constructed for the service, and there are cases wherein the whole distance from Shanghai to London has been performed at an average speed of over eleven knots per hour, the time occupied but little exceeding thirty-eight days. These results have been obtained in vessels receiving no state aid, but depending solely upon their freights and passenger money. As an average speed for ordinary merchant steamers, however, from eight to nine knots per hour is probably not far from the truth on these long voyages, this average being about equal to the average speed of the *Great Western* and other early trans-Atlantic steamers which were regarded as exceptionally fast vessels forty years ago.

To Australia the distance *viâ* the Suez Canal is only about nine hundred miles less than *viâ* the Cape of Good Hope, and, consequently, steamers run on both routes. In 1875 a passage was made from Plymouth to Melbourne *viâ* the Cape which at the time was considered most remarkable, although it has since been surpassed. The *St. Osyth* left Plymouth on the 12th of May, at 11.30 p.m., called at St. Vincent for coal, and thence steamed continuously to Melbourne, which she reached on the 27th of June. Her full steaming time was about $43\frac{1}{2}$ days, her average speed was $11\frac{6}{10}$ knots per hour, and on the 10,000 miles run from St. Vincent to Melbourne she stopped steaming only three times, for $2\frac{1}{2}$ hours in all—to screw up the engines; this same ship made several voyages of nearly the same character. But the Orient Line of steamers since placed on the Australian trade have done still better. For example, the *Lusitania*, in 1877, made the passage to Melbourne in $40\frac{1}{4}$ days, including a detention of $1\frac{1}{4}$ days at St. Vincent, while coaling. Her actual steaming time was almost exactly 39 days, and her average

rate was only a little under thirteen knots per hour. Another vessel of the Orient Line, the *Cuzco*, in the summer months of 1879 made the voyage home from Adelaide to Plymouth in 37 days 11 hours, including all detentions. One of the latest additions to this fleet, the *Orient*, has made some excellent performances.

Vessels of other lines have done almost equally well, and we thus have evidence that marine engineering has attained such perfection that the longest navigable distances can be successfully traversed at high speeds.

For those who prefer a change of route in going to and returning from Australia, there is the possibility of making the outward voyage *viâ* the Cape of Good Hope, and the homeward voyage from Australia to San Francisco, then overland across America, and finally by steamer from New York to Liverpool. The trans-Pacific line from San Francisco to Sydney of course does not compare in length with that from England to Sydney; being only 6,400 miles against 11,600; but then there is the trans-Atlantic passage of 3,000 miles, and the long land journey in addition. The American Pacific Mail Company have the largest share in the traffic from San Francisco to China, Japan, and Australia; and the attempts made by English companies to compete with the American line have not hitherto proved very successful.

It must not be supposed, however, that American steamers monopolise the Pacific trade. There is an English Pacific Steam Navigation Company which stands high on the list of our great companies, and has now been in operation over forty years. This company was originally established for the purpose of promoting commerce and communication on the Pacific coast of South America, working in concert with the West India Mail Company, whose steamers ran to Colon on one side of the Isthmus of Panama, while the Pacific Company's steamers made Panama their terminus and starting port. After more than twenty years of this limited but useful service the range of the operations was extended; and in 1867 a direct service of steamers was established from Liverpool to Valparaiso, *viâ* the Straits of Magellan. At the present time a steamer is despatched from Liverpool about once a month for South America, proceeding as far as Valparaiso, and the whole voyage of about 9,000 knots is accomplished in about six weeks, including stoppages at Bordeaux, Lisbon, some Brazilian ports, the River Plate, &c. Some of the most successful vessels originally built for this service, are now employed on the Australian line, where their high reputations for speed and seaworthiness have been well maintained.

Two other companies, whose steamers traverse long distances at high speed, are the Union Steamship Company and Messrs. Donald Currie and Co.'s line to the Cape of Good Hope, Zanzibar, and Mauritius. Special attention was naturally drawn to these vessels during the Zulu war, and their performances were excellent. In April, 1879, the *Durban* made the passage from Cape Town to Plymouth, calling at Madeira, in 18 days 23 hours, including 5 hours' stoppages. Her average speed was about thirteen knots per hour, over a distance of nearly 6,000 knots. Another remarkable passage was made by the *Manora*, a steam-ship which had been chartered from the British India Company for the special purpose of conveying reinforcements to the Cape. She accomplished the voyage in 21½ days, and was detained at St. Vincent for thirty-eight hours while coaling. Her steaming time was 478 hours, and the distance traversed was about 6,200 miles, her average speed being nearly 13 knots. In September, 1879, the *Pretoria*, another steamer of the Union Line, made the passage to Plymouth from the Cape, *viâ* Madeira in 18 days 13¼ hours, including 5¾ hours' stoppages.

INDUSTRIAL LEGISLATION.—XI.

THE FACTORY ACT OF 1844—THE TEN HOURS ACT OF 1847.

BY JAMES HENDERSON, ONE OF H.M. SUPERINTENDING INSPECTORS OF FACTORIES.

As may be supposed, the close divisions which had taken place in the House of Commons on the Government Factory Bill created an unusual amount of interest and excitement in the manufacturing districts. The proposals both of the Government and of Lord Ashley having been rejected, the way seemed open, in the opinion of many, for a compromise, and for a time there was a talk of an Eleven Hours Bill being proposed and accepted. The suggestion did not receive much support, however; the Government expressed a determination not to give way, and the friends of the Ten Hours clause

were buoyed up with the hope that if they but continued to press their claim with earnestness they would be certain to be successful. Sir James Graham did not lose much time in re-introducing the new Bill which he had promised, and which was found in its most essential features to be practically the same as that which had been withdrawn. Lord Ashley brought the question between himself and the Government to an issue by moving a new clause when the Bill was before the House on the 10th of May, and by which he proposed to restrict the employment of young persons in factories to fifty-eight hours a week on and after the 1st of October, 1847. His lordship made a powerful speech in support of his proposal in which he recapitulated with much force the arguments in favour of the Ten Hours restriction. He was answered by Sir James Graham, the Home Secretary, who took the House by surprise by distinctly intimating that the Government proposed to treat the question as one of confidence, and to stake their existence as an Administration on the division. The debate which followed was a protracted one, and it was ultimately adjourned till Monday, the 13th of May. It was closed by a speech from the Prime Minister, Sir Robert Peel, who emphatically repeated the declaration of the Home Secretary that the Ministry would resign if the vote went against them. The threat was not without its influence, and on the division being taken it was found that the Government had an overwhelming majority. There voted in favour of Lord Ashley's clause, 159; against it, 297: majority for the Government, 138. It could not be denied but that this was a crushing defeat to the promoters of the Ten Hours Bill, and it was all the more severely felt because it was so unexpected. No fewer than sixty-one members of the House of Commons who had previously voted for a Ten Hours clause, on this occasion were either absent or voted with the Government, and the majority was largely increased by members who had not previously voted on the question, and who now responded to the appeal made to them by the Prime Minister.

However, although disappointed, Lord Ashley and his friends were not discouraged. The vote of the 13th of May on the clause which he proposed decided the point for a time, and the Government Bill passed through its subsequent stages in both Houses without difficulty. The noble lord frankly avowed his intention of returning to the question as soon as he had an opportunity.

Although the Factory Act of 1844 failed to satisfy the advocates of a Ten Hours Bill, it yet proved a most important and valuable measure. It was far in advance of anything which had preceded it in the statute-book for regulating the hours of employment in factories, and for promoting the health and comfort, and providing for the safety and protection of the workpeople. The administrative machinery established by this Act practically remains to this day, and it is almost impossible to over-estimate the beneficial influence of the system of combined employment and instruction which it established in the case of all children employed in factory labour. Men are not unfrequently to be met with in the manufacturing districts of the north who have risen to an honourable and influential position in life, whose school education was limited to that which they received under the half time system established by the Act of 1844. The great value of this portion of the Act consisted, however, in the impetus which it gave to the development of a national system of compulsory education, such as we now enjoy under the Elementary Education Act of 1870.

The session of 1845 passed over without any effort being made in Parliament to renew the agitation in favour of a Ten Hours Bill, but early in 1846 Lord Ashley returned to the subject with unabated energy and determination. He re-introduced the Ten Hours Bill in the House of Commons on the 29th of January, but an untoward event occurred at this time which interrupted his lordship's parliamentary career. The agitation in favour of the repeal of the Corn Laws had reached a climax, and the Government had assented at last to their abolition. Lord Ashley, who then sat in the House of Commons for Dorsetshire, approved of Sir Robert Peel's policy on this question, and supported him. Having been elected as a Protectionist, however, he conceived it to be his duty to resign so that his constituents might have the opportunity of expressing an opinion on his conduct. On offering himself again as a candidate he was rejected, and for a brief period he was without a seat in the Lower House of the Legislature. In his absence, Mr. John Fielden, then member for Oldham, took charge of the Ten Hours Bill, the second reading of which was debated on the 29th of April. The discussion was not concluded when the sitting was suspended, and it was resumed on the 13th, and again on Wednesday, the 22nd. The Government continued to offer an uncompromising opposition to the Bill, Sir James Graham, the Home Secretary, having spoken

vigorously against it. Notwithstanding, when the division took place, the second reading was rejected only by a majority of 10, the numbers being—for the Bill, 193; against it, 203.

Probably, under any circumstances the important political events which marked the remainder of the parliamentary session of 1846 would have prevented any further progress being made with this Bill. On the 26th of June the royal assent was given to the measure repealing the import duties upon corn, and on the same day the Government sustained a disastrous defeat on the Irish Coercion Bill, which immediately led to their resignation. The late Earl Russell was entrusted with the formation of the new Ministry, and as he and other leading members of the Whig party had consistently supported the Ten Hours Bill, the hopes of its friends at the prospect of final success were strong. During the winter of 1846–7 a vigorous agitation was maintained throughout the country in favour of the Bill. Lord Ashley visited Lancashire, where he was received with acclamation, and when Parliament assembled in the spring of 1847 the influence of these exertions made itself at once apparent. Mr. Fielden re-introduced and moved the first reading of the Ten Hours Bill at the very earliest opportunity. With the new Ministry it was held to be an open question, and the debates upon the second reading disclosed a wide diversity of opinion respecting its merits among those who were accustomed to act together politically. The motion that the Bill be read a second time came on on the 10th of February, and Mr. Joseph Hume led the opposition, being supported by Mr. Bright, Dr. Bowring, Mr. Mark Phillips, and Mr. Roebuck. Among the speakers in favour of the measure on this occasion were Mr. Fielden, Lord John Manners, Mr. Newdegate, Mr. Muntz, Mr. Sharman Crawfurd, and Sir Robert Inglis. Sir Robert Peel was consistent in his opposition to the Bill, and spoke with some degree of contempt of the arguments of its promoters. When the division was taken on the 17th of February, to which day the debate had been adjourned, it was found that the second reading was carried by a large majority—195 members voting for the Bill and only 87 against it.

From this point onwards the success of the Bill was assured, and great were the rejoicings among the operatives in the textile manufacturing districts. The strongest expressions of gratitude were tendered to Lord John Russell for the support he had given to the Bill, and the feeling in favour of it both in Parliament and the country could not be resisted. On the 3rd of March the measure was again under discussion in the Commons, but it was sustained by a majority of 90 on a division being taken. On the 17th of the same month, on another division, the majority was 78; and finally, on the 3rd of May the third reading was agreed to by a majority of 88. In the House of Lords it was not anticipated that any serious opposition would be offered to the Bill, and this proved to be the case. Lord Brougham delivered a most vigorous and somewhat characteristic protest against it, but on the division being called on the second reading, the Bill was carried by a large majority, 53 voting in favour of it, and only 11 against it. The Earl of Ellesmere and Lord Feversham took charge of the Bill in the House of Peers, and the royal assent was given to the measure on the 7th of June, 1847.

The Factory Act of 1844 sanctioned sixty-nine hours per week as the working time for women and young persons; the new Act limited these hours to sixty-three from the 1st of July, 1847, and to fifty-eight from the 1st of May, 1848. The weak point in the Ten Hours Act of 1847, however, was that it allowed the period of employment fixed by the Act of 1844 to remain unaltered. The ten hours a day of actual work could be taken between half-past five in the morning and eight o'clock in the evening, and the opportunity this offered of evading the Ten Hours Act was immediately taken advantage of. The mills were kept running during the full period of employment, professedly with relays of hands, but the inspectors found it impracticable to check the most flagrant breaches of the law under such a system. The result was that the Ten Hours Act was hardly registered upon the statute-book ere the necessity of amending it was made apparent to those whose duty it was to administer it.

This fly in the pot of ointment was not discerned for a time, however, by the supporters of the Ten Hours Bill, who throughout the textile manufacturing districts indulged in most exuberant rejoicings. After fourteen years of constant and incessant agitation their efforts appeared crowned with the most perfect success, and they might well be excused for congratulating themselves on the result. An important meeting of the promoters of the Ten Hours Bill, and of the delegates from the manufacturing districts was held in London on June the 2nd, which was presided over by Lord Ashley. A series of resolutions were passed expressive

of gratitude to those who had perseveringly laboured in the cause which had just been brought to such a successful issue. Among those named in these resolutions were Lord Ashley, the first Sir Robert Peel, Mr. Nathaniel Gould, Mr. Thomas M. Sadler, the Earl of Ellesmere, Lord Feversham, Mr. John Fielden, Mr. J. Brotherton, Mr. Aglionby, Mr. John Wood, Mr. R. Oastler, Mr. W. Walker, the Rev. G. S. Bull, Mr. Philip Grant, Mr. James Turner, and Mr. Mark Crabtree. Two days subsequently to the holding of this meeting, Lord Ashley addressed an interesting letter to the Short Time Committees of the counties of Lancaster, York, and Chester, from which we may quote a few sentences. His lordship said: "First, we must give most humble and hearty thanks to Almighty God for the unexpected and wonderful success that has attended our efforts. We have now the great object of our labours—the Ten Hours Bill has become the law of the land; and we hope—nay, more, we believe—that we shall find in its happy results a full compensation for all our toils. But with your success have commenced new duties. You are now in possession of those two hours which you have so long and so ardently desired; you must, therefore, turn them to the best account,—to that account which was ever in the minds of your friends and advocates when they appealed to the Legislature in behalf of your rights as immortal beings, as citizens and Christians.

"You will remember the principal motive that stimulated your own activity and the energetic aid of your supporters in Parliament was the use that might be made of this leisure for the moral improvement of the factory people, and especially the female workers, who will now enjoy far better opportunities both of learning and practising those duties which must be known and discharged if we would have a comfortable, decent, and happy population."

The Act of 1847 had hardly come into complete operation ere the defect to which we have referred betrayed itself. When carried out in its integrity, the Act was unquestionably most beneficial and satisfactory to the workpeople, and as employers found that the exaggerated evils which were prophesied respecting it were never realised, they became more and more reconciled to it. But the discovery that the law could be practically evaded by adopting the "shift" or "relay" system, caused much uneasiness. The conditions under which such a trade as the cotton manufacture is carried on are so stringent and keen, that an employer could not afford to allow a competitor such an advantage as was obtained by adopting this system. The consequence was that it rapidly extended. The factory inspectors strove in vain to check it; they instituted numerous prosecutions, but the decisions they obtained were contradictory and unsatisfactory. Finally, the legality of the relay system was tested by the operatives themselves, by a friendly action brought against a manufacturer at Heywood, in Lancashire, who was favourable to the strict enforcement of the Ten Hours Bill. The Court of Exchequer, when appealed to, ruled that the "shift and relay" system was not contrary to the letter of the Factory Act of 1844 as amended by the Act of 1847. This settled the question, and it was at once resolved again to appeal to Parliament, in order that the integrity of the Ten Hours Bill should be maintained.

Lord Ashley, meanwhile, had regained a seat in the House of Commons, having been returned for the city of Bath at the general election. When the session of 1850 opened he at once undertook to introduce a short declaratory Bill, which would have the effect of suppressing the relay system. He was met by the Government with a suggestion which offered a very satisfactory compromise. Sir George Grey, then Home Secretary, proposed to fix the period of employment for young persons and women from six in the morning till six in the evening in summer, and from seven in the morning till seven in the evening in winter, with an interval out of this of one hour and a half for meals, and that all work should cease at two o'clock on Saturdays. The effect of this proposal was to increase the number of working hours during the week from fifty-eight to sixty, but it promised this important advantage, that it rendered the enforcement of the Act absolutely certain.

The supporters of the Ten Hours Act were divided in opinion as to the propriety of accepting this compromise, and a correspondence which took place in the public press many years subsequently indicated that a bitter feeling had been provoked among some of them. Lord Ashley, Mr. John Wood, Mr. Philip Grant, and others approved of the Government proposal, while Mr. Oastler, Mr. Walker, and the Fieldens and others were opposed to it. Sir George Grey introduced a Bill to give effect to his suggestion, and Lord Ashley withdrew his measure. The Government Bill was assailed from both sides, Lord John Manners moving an amendment in favour of the ten hours, pure and simple, and Mr. Bright another, legalising the relay

system. Both, however, were defeated, and the Act passed without much difficulty. The experience of the subsequent four and twenty years fully established the wisdom of this settlement. Up till 1874, the hours of employment for women and young persons remained as fixed by the Act of 1850, and while they proved acceptable to the employers, they were never felt burdensome or oppressive by the workpeople. During the quarter of a century which this period embraced, the social and industrial progress of the textile manufacturing districts was something marvellous. The health, the habits, and the manners and customs of the people improved to a degree which only those who have resided in these districts, and who have compared the past with the present condition of things, can understand and appreciate. None but a few irreconcilables ever objected to Sir George Grey's Act of 1850. Of the Act of 1874, which repealed it, we will have something to say later on; judging from the criticisms now passed upon it, if it were to be proposed to-day it would indeed have a slender chance of getting enrolled on the statute-book.

INDUSTRIAL ART.—VI.

ART IN TEXTILE FABRICS.—FIRST PAPER.

By John Forbes-Robertson, Author of "The Great Painters of Christendom."

By "textile fabrics" is meant any woven fabric, the materials of which may be of silk, wool, cotton, hemp, flax, jute, or combinations of these —the humblest fibre of them all being capable of artistic manipulation. With the fresh discoveries of naturalists will, doubtless, come other materials, but whatever their character, they will be regarded, when woven, as textiles.

Within the last quarter of a century woven fabrics of all kinds, from cottons to carpets, have been made the subject of empiric æsthetics, and public taste has advanced with the general education of the country, and with a more familiar knowledge of those principles which are applicable to whatever the hand of man would adorn and beautify.

Much of what has been said, therefore, of art practice in clay and iron is applicable to textiles; materials may vary, but art-principles are immutable. What is to be guarded against is not only falsity of form, and crudeness of colour—the form, how perfect soever, must be in the right place, and with the right surroundings, in order that artistic association may not be violated; because upon this mental co-relation depends what is called "style." The word, in the way we now use it, is applicable to the art work of any country or period; and in such art work there is always a certain characteristic homogeneity differentiating it from all others, which has received the *imprimatur* of our historic sense, and therefore universal currency for what it is.

For example, it would be an outrage in our ideas of association were we to see in a floor-covering a piece of rich, soft, Persian design, alternating with the flaunting flowers which used to jump at us from the ordinary Brussels carpet of thirty years ago. The incongruity of such a combination would strike painfully the most ordinarily trained eye. That such re-arrangements, in every branch of the arts, are possible, we readily admit; but it is only the re-combining, re-constructing mind of genius that can venture upon such novelties—for all purposes of ordinary art-progress the designer had better keep to the beaten ways.

In our present chapter, we purpose saying a few words on art in tapestry, or arras, as it was once called, from the fact that the Flemish town of that name was the centre of tapestry-making in the fourteenth century. Originally, however, it was called *Sarrazinois*, or *opus Saracenum*, showing, apparently, that the monks, who were the first makers of the fabric in Western Europe, had acquired the art from the Spanish Moors. In like manner the Romans called embroidery "Phrygian" work. Some authorities maintain that the famous Bayeux tapestry, representing the whole story of the Norman conquest of England, was really made in London, towards the end of the twelfth century, and was presented by Henry II. to the rebuilt cathedral of Bayeux.

On examining, however, the photographic reproduction of this fabric in the South Kensington Museum, it will be found to differ very much from what we understand by tapestry. In tapestry

proper the worker forms the tissue, or fabric, as he makes the pattern line by line. There is a warp, which may be upright, as in Gobelins work, with the picture, or pattern behind it; or it may be nearly horizontal, with the pattern underneath, as in the tapestry of Beauvais, but in no case is there a weft. The process of working makes the weft. The Bayeux tapestry on the other hand is simply embroidery, worked with the needle on coarse linen, and in one sense it may be termed a gigantic example of sampler work; and whenever any reference is made in Scripture to working on fine linen it is probable that the needlework was of the Bayeux order. We are told, for example, in Exodus (xxxv. 35), that Aholiab, son of Ahisamach, of the tribe of Dan, was "an engraver, and a cunning workman, and an embroiderer in blue, and in purple, and in scarlet, and fine linen." Ezekiel speaks repeatedly of "broidered work" in connection with Tyre. In the grand lamentation which the Lord bade him take up for that city "at the entry of the sea," this passage forms part of his sublime apostrophe:—"Fine linen with broidered work from Egypt was that which thou spreadest forth to be thy sail; blue and purple from the isles of Elishah was that which covered thee" (xxvii. 7).

The art-textiles of Babylon became, in their turn, equally famous, and Josephus tells us that the veils of the Temple were the products of her loom.

Nor have Pagan poetry and legend been unmindful of the weaver's art. We all remember and admire that *textrix* whose web filial piety filled by day—and love, loyalty, and hope undid at night. But more melancholy than the lot of Penelope was the fate of the beauteous Arachne, that Lydian maiden who used to weave the thread which her father, Idmon, dyed. So much delight had she in her work, that she very soon excelled all the damsels of her time; but with her increasing fame gradually crept in pride, till in an evil hour the deft-fingered, bright-eyed girl challenged Minerva to a trial of skill at the loom. The earthly maiden wrought in her web the pictured story of the amours of the gods, and the haughty Athena, unable to find fault with its matchless cunning, tore the fabric to pieces. This was too much for the art-loving enthusiastic Arachne, and the poor maiden went straightway and hanged herself. An ironical remorse came to the cruel breast of the goddess, and she cut her poor victim down; but the rope became a thread and Arachne a spider. Hapless, yet immortal Arachne! who can gaze on thy fragile gossamer, as, diamonded with dew, it trembles on the autumn bush, without acknowledging that thou art still the most marvellous of weavers! Whether such legendary works were the products of the loom or of the needle we shall probably never know, and we only refer to them to show that textiles are probably the oldest of all our industries.

There can be no doubt that from the thirteenth century onwards the true texture of tapestry ran through the gorgeous stuffs which draped the walls of our manor houses, and palaces, and were hung from city windows on grand festive occasions, to celebrate princely bridals or welcome some conqueror whom, in imagination, we see advancing in all the pride of processional pomp and bravery amid the huzzas of the people, the blare of trumpets, and the air-filling clang of bells.

That tapestry was made from time to time in England previous to the sixteenth century, is beyond dispute, for in the ante-Reformation period many of our monasteries were tenanted by foreign monks. English embroidery, indeed, had quite a reputation abroad, during the thirteenth and fourteenth centuries; but tapestry proper never took permanent root in this country, and was always regarded by the English as a foreign art.

Even when the Stuart kings James I. and Charles I. gave very practical assistance to Sir Francis Crane and his coadjutors, in establishing a manufactory at Mortlake, in 1619—a specimen of the tapestry made there is to be seen at Hampton Court, and another, as Mr. Becker informs us, is in the possession of the Duke of Buccleuch—the works were of no long duration. It is true the art-loving Charles had five of Raphael's cartoons, which Rubens had purchased for him, worked at Mortlake, and so keen was his desire to carry on the concern that he purchased the whole establishment from Sir Richard Crane, the brother and successor of Sir Francis. It is true also that the factory was continued throughout the Commonwealth; but during the reign of the easy-going, impecunious Charles II., the business appears to have collapsed, and not till a century later do we hear anything more of English-made tapestry.

About the beginning of the second half of the eighteenth century a similar venture was established at Soho, and the authority already quoted tells us that there was a room in Northumberland House hung with large pieces of tapestry designed by Francesco Zuccharelli, consisting of his usual landscapes and figures. This praiseworthy attempt, in the reign of George II., to establish tapestry works

in England had a shorter "run" than its predecessor, and we were again thrown back upon Flanders and France for this most gorgeous and costly of all decorative textiles.

Almost every town in Flanders in the sixteenth century made tapestry, and France very soon followed the example of the Low Countries. Francis I. established a factory in France which was maintained with more or less of success for several reigns, especially during that of Henry IV., who re-established the industry in the suburbs of Paris. The great revival of the art, however, took place in the reign of Louis the Magnificent, when he sanctioned the purchase, by his minister Colbert, of the works founded in the reign of Francis I., by Jean Gobelin, who introduced from Venice the art of dyeing scarlet. These works, at the time of their purchase, were used for tapestry weaving on a limited scale by a Dutchman named Gluck, but were soon enlarged by Colbert, and converted, in 1667, into a royal factory. Charles le Brun,* the first President of the Royal Academy of Painting, the formation of which had been confirmed by letters patent in 1649, was appointed director and designer, and the work produced called forth the admiration even of the Flemings, who first brought the art to France. Such was the beginning of the famous Gobelins factory, of which Beauvais and Aubusson are offshoots. War was in the main the theme of Le Brun's pencil; but when we come to Boucher and his school, court pastorals are the subject, and daintily attired shepherds and shepherdesses minced elegantly about in the tapestries of Beauvais till the French Revolution came and swept them for a time from sight. We say "for a time" because tapestry, like all art, has its fluctuations and its fashions. What delights in one age may give æsthetic disgust to the next, and yet be hugged with gushing raptures by a third.

These remarks have been made chiefly to introduce to our readers the tapestry works at Old Windsor, which, at the suggestion of Mr. H. Henry, their director, were established in 1877, under royal sanction, with the late Duke of Albany for President, Lord Ronald Gower for Honorary Secretary, and a large number of the most distinguished of our nobility as an acting committee. The factory, like the School of Ornamental Needlework at South Kensington, is self-supporting, and both institutions are being largely employed. To the Royal Windsor Tapestry productions exhibited in the Prince of Wales's pavilion was awarded a gold medal at the Paris International Exhibition of 1878, and the lady-workers at South Kensington had the honour of carrying off a silver one. That much good must result from the establishment of two such institutions no one at all interested in art matters can for a moment doubt.

The workers at Windsor produce their own dyes, and already they possess twelve thousand different shades of colour. They have never yet, however, been able to produce a true flesh-tint, owing to atmospheric influences peculiar to our climate. Further chemical experiments will, doubtless, overcome this difficulty; and in the meantime we do not see that any great loss is sustained. Naturalistic treatment in tapestry, as in mural paintings, or frescoes, is rather to be avoided.

Indeed, all textile fabrics, whether curtains, carpets, tapestries, or dresses, ought to be treated rather conventionally, with a leaning towards archaism, rather than naturalism. Above all, the chiaroscuro of Correggio is to be avoided. Modelling and rotundity are admirable enough in a painting proper; but for the decoration of a wall or a floor, where textiles, or even mosaics, are introduced, flatness of treatment is a *sine quâ non*. In the best art periods of all countries, from Egypt downwards, this was well understood, the cartoons of Raphael notwithstanding; and even in his case the works were on so large a scale, and the figures, for the most part, so much in one plane, and without any great suggestion of Correggiosity, that no architect would complain of holes being made in his walls, by the display of such works.

The Royal Windsor manufactory employs not only the most promising of our Royal Academy students, but the Academicians themselves, and the late E. M. Ward, R.A., was one of their earliest designers and is the author of several admirable hunting subjects. Mr. J. E. Hodgson, R.A., produced a design representing "The Saving of the Colours of the 24th Regiment by Lieutenants Coghill and Melville," while Mr. John O'Connor, the famous scene painter, has prepared a "View of Windsor Castle."

Good form and rich colour are the essentials of tapestry, and these may be applied to any style or school that suits the designer. Many of the Windsor girls are employed at the factory mending old tapestry; and sometimes, when a part of the design has been torn off, the workmen are able to add on a new piece; and so cunningly are they joined that none

* *See* "The Great Painters of Christendom," p. 307.

but an expert would be able to distinguish between the old and the new.

Mr. Henry, to whose enterprise and intelligence the establishment of the Royal Windsor Tapestry Works is wholly due, intends training English youth in a practical knowledge of the art; and before long we hope to see this, one of the most beautiful of our art industries, expanded like our carpet works, into such national dimensions, as will attract both the admiration and the custom of other lands. If the carpets which covered the floor of the Prince of Wales's Pavilion at the 1878 Paris Exhibition, and which were manufactured by Templeton of Glasgow, were deemed by capable judges equal in colour and design to old Persian, we see nothing to hinder the products of Windsor one day rivalling in beauty the tapestries of the Gobelins and Beauvais, Bruges and Arras.

POTTERY AND PORCELAIN.—VII.

PORCELAIN—JOSIAH WEDGWOOD—THE ETRURIA WORKS.

By James Francis McCarthy.

PORCELAIN, or china ware, as it is familiarly called, is the refined branch of the ceramic art. The purely mechanical operations involved in its production require on the part of the potter perfect and exact workmanship; while the ornamentation of porcelain is so much the result of cultured skill that it approaches high art. This happy union of the beautiful with the serviceable is realised in the manufacture of superior china ware, which can now be purchased by persons of moderate means, and is no longer what it used to be, a treasure of the household which only the very wealthy could hope to possess. In porcelain, moreover, the choicest articles of ornament are made—fragile it is true, but with a fragility of exquisite loveliness. Probably in a greater degree than any other art-industry does that relating to porcelain appeal to and realise our ideas of the beautiful. The literature of porcelain attests the fascinating influence it has over the mind of the learned in art and the cultured in taste. Voluminous as this literature already is—dealing as it does with the subject historically, critically, and speculatively—it is constantly receiving additions from modern writers. Apart from the purely artistic aspect of the subject, which would necessarily partake of a critical disquisition, the production of porcelain regarded merely as a manufacture is extremely interesting.

Porcelain, like many other inventions which have contributed to the higher necessities of civilised life, originated with the Orientals. It is now a matter of no speculation or dispute that porcelain was produced in China sixteen hundred years before it was known either on the Continent or in this country. Two hundred years before the Christian era the Chinese, with all the subtle ingenuity of their race, were fashioning porcelain articles which for their intrinsic beauty are unsurpassed, if indeed they are equalled, even in this age of progress. We first hear of real porcelain being introduced on the Continent at the close of the sixteenth and the beginning of the seventeenth centuries. It is true a spurious description of china was made at Florence in 1580; but it was not till 1695 that we have authenticated evidence of the production of porcelain in its purity. This was at the St. Cloud works, the forerunner of the famous Sèvres manufactory. England was certainly not behind some Continental countries in the manufacture of this later and more beautiful outgrowth of pottery. At Fulham, porcelain, not quite pure and of a somewhat coarse description, was made before it was produced in Germany. But there is some doubt about the exact date when these works commenced. A porcelain manufactory was established at Bow in the East of London about 1730, and continued till 1775. Then, under royal patronage, the Chelsea Works were formed in 1747. The opening of the Derby Works took place in 1750, and a year later the famous Worcester Royal Porcelain Works were started. In Plymouth china was made in 1768, at Coalport in 1772, and in Bristol in the same year. In North Staffordshire the names of Spode, Mason, Davenport, Minton, and last, but by no means least, Josiah Wedgwood, are familiar to those acquainted with the industry, if not as among the earliest, at least, as some of the most skilful makers of porcelain. In the Potteries the manufacture of china commenced about a hundred years ago. Most of the porcelain works which have been mentioned have either

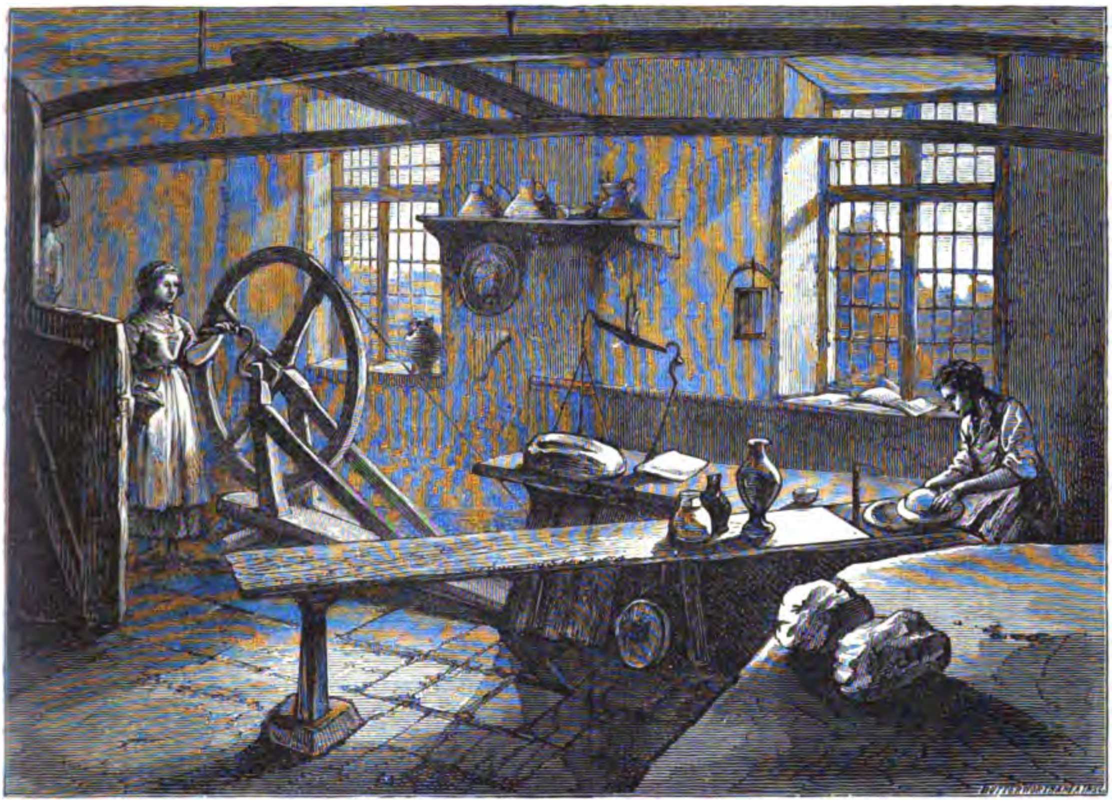
ceased to be altogether, or have been transferred to other establishments in North Staffordshire.

In giving a brief account of English porcelain considered as a vigorous English industry, which it has now become, we shall ascertain much about the subject, and other higher branches of pottery, by a description of Wedgwood's works at Etruria, in the Potteries. Of course there are larger porcelain manufactories than Wedgwood's, but nowhere is it to be seen in greater beauty or more absolute perfection. Besides, there is a special interest connected with the name of Wedgwood which gives it a precedence that no living pottery manufacturer, however eminent his position in this industry may be, will consider inappropriate or undeserved. To Josiah Wedgwood—the originator of the existing works at Etruria—English pottery owes more than to any other person. It was his persevering labour—labour that never tired until it had accomplished its great work — his philosophic inquiries, incessant experiments, and a perseverance that conquered all difficulties, that gave to English pottery in its initial stages a perfection and a refinement which raised it to the dignity of art industry, placed it on an equality with the work of our Continental neighbours, saved it from reproach, and endowed it with commercial vitality. That great statesman, orator, essayist, and critic, Mr. Gladstone, paid a noble compliment to the genius of labour when, speaking of Wedgwood, he said: "When the day shall come when England is celebrated for the beauty of her manufactures, my belief is that the result will probably be due to no other man in so great a degree as to Wedgwood."

JOSIAH WEDGWOOD.

The story of Wedgwood's life and labours has been told with graceful minuteness of detail, and as a record of the struggles and successes of one of England's greatest industrial worthies, it possesses an earnest charm, which fiction in its most attractive form fails to yield. When we remember the disadvantages under which Wedgwood laboured, the work he did perform creates a greater feeling of admiration. He was born in an age when what is now regarded as the most rudimentary knowledge was not within the reach of the multitude; but, on the contrary, was regarded in the nature of an accomplishment of the wealthy only. He laboured in days when technical education and instruction in any of the arts, as necessary aids to skilled workmanship, were undreamt of. Yet, notwithstanding these disadvantages, Wedgwood imparted to the work which came from his place such artistic finish, such beauty, and such a grace, that had not before been associated with English pottery. No wonder that connoisseurs, lovers of art, and admirers of what is beautiful in finished labour, as well as crowned heads, and the titled great, one and all vied in admiration of Wedgwood's wares; and by their praises made his work universally famous. This was the success which arises from that "patient faith" which never wavered under repeated failure, and of that earnestness of purpose, which in ordinary men would have lapsed into despair, if, as in the case of Josiah Wedgwood, it had been so often confronted by great and perplexing difficulties. This perseverance—one of Wedgwood's strongest characteristics—receives illustration by an incident in connection with the production of the famous Portland vases. It affords one of the glimpses into the inner nature of the man which reveals its force more than could be told in volumes. The task of imitating the Portland vases in the form of jasper ware was no easy one, and in undertaking it no one knew better than Wedgwood how much depended on the issue. The vases were moulded

time after time, but as often, when submitted to the crucial test of firing, they were drawn from the oven in an unsatisfactory state. Again and again the vases were formed in plastic clay, with irreproachable symmetry. Either the fire was unkind, or the materials were faulty, but for six months there were persistent and disheartening failures. At the end of this time, one of the workmen, after further proof of non-success, addressed Wedgwood in despair, "Master, we have drawn the oven again, and we haven't got a single good vase." Wedgwood's reply was characteristically homely and terse: "Well, you have had your wages, haven't you? Go on." The trials did proceed, and shortly after, the celebrated vases, the admiration of connoisseurs, were produced, with a fidelity to the original which until the result was obtained, was thought to be impossible.



WEDGWOOD AT WORK.

Josiah Wedgwood was born in 1730, was apprenticed when he was scarcely twelve years old, and at that early age was doing the work of "throwing" with a proficiency which older hands could not excel. Then came a period of illness followed by the amputation of one of his legs, which compelled him to take to other branches of the industry. He loved his work with a devotion which was rare. In his infancy, as in his manhood and old age, his associations were identified with North Staffordshire pottery. In 1759, after his partnership with John Harrison, Wedgwood entered on his own business career at the Ivy House Works. Soon after, the art which he infused into his ornamental and green-glazed pottery ware began to be recognised. Simultaneously he was making remarkable improvements in the decoration of his work. Two years after commencing business on his own account, Wedgwood had perfected his cream-glaze ware; and so much did this increase the popularity of his manufactures that an export house was opened in London. Then followed more experiments, pursued with many a disappointment and at the trial of much patience, but finally resulting in success. Later on began the remarkable acquaintance with Thomas Bentley, an acquaintance that soon ripened into a deep mutual affection. It was a friendship so sterling, and withal so

tender, that in the record of so much hard work it gives to Wedgwood's life a pleasant touch of sentiment. Bentley, himself a man of learning and taste, entered into the artistic spirit of Wedgwood with equal enthusiasm. It was owing to his influence that the amiable Chisholm and the gifted Flaxman were engaged as designers at the Etruria Works, which were erected in 1770. The work of these great artists, as perpetuated on jasper ware, is now, as it was then, the most perfect of its kind; and to-day, as it was a hundred years ago, evokes our deserved admiration. Soon after the Etruria Works were started, the character of the neighbourhood from an industrial and social point of view underwent a rapid and a great change. In the words of Smiles:—"From a half-savage, thinly-populated parish of some 7,000 persons in 1760, partially employed, ill-remunerated, we find an increase in the course of some twenty years of about double the population, abundantly employed, prosperous, and comfortable. Could the power of industry, directed as it was in this case by a master mind, be more forcibly or happily illustrated?"

The Etruria Works are now somewhat different from what they were in the days of Josiah Wedgwood. They have passed into the hands of his great-grandsons Godfrey, Clement, and Lawrence Wedgwood, by whose courtesy I was enabled to visit this famous establishment. The increasing demands of trade rendered necessary an extension of the premises. Externally, the Etruria Works present much the same appearance as they did in the days when Josiah Wedgwood's young hands fashioned soft clay in one of its low-roofed rooms. There is the same queer-looking cupola building at one end; the same little excrescence-like office jutting from the main building; the same belfry surmounted by the weather-cock. There is the same clock fixed in the gable underneath, which, like the brick-work, is dingy with age, so that when the sun glints on its weather-beaten face, the figures on the blackened dial shine in a rusty-golden hue. On the other side of the canal to that on which the Works stand, there is a bright view of scenery—of wooded hill and dale, dotted here and there with the evidences of the staple industry of the place.

Here for the present we may pause before passing through the Etruria Works to see the beautiful results of art and handicraft which are manufactured in that historical establishment.

COTTON.—XXV.

MANCHESTER AND THE COTTON MANUFACTURE—EARLY CUSTOMS OF THE TRADE—ON 'CHANGE—A PEEP AT THE WAREHOUSES IN OLDHAM, ETC.

BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

MANCHESTER is the chief seat of the cotton manufacture, and as such its name and fame are more widely known over the face of the earth than perhaps those of any other city. The enterprise of its merchants seems to know no bounds. Not only have they established connections in every leading market of the world, but they have wandered far from the beaten tracks of civilised commerce, and found purchasers for their wares in the heart of "the dark continent," and the remotest isles of the sea. They supply clothing to a large proportion of the human race, and rank among their customers the very people who, in distant lands, grow for them the raw material of their trade. We have seen how in the early days of the cotton manufacture Lancashire men distinguished themselves by inventing machines to supersede hand labour in the production of cotton goods. With unwearied perseverance and marvellous skill they continue to work in the direction of improvement, and scarcely a week elapses without something new being produced. Working hand in hand, the manufacturer and the merchant have achieved results for their country and for mankind that will long redound to their fame. By sheer force of character and intellect they have in a brief space of time raised an alien material from the position of a hardly recognised competitor with the native flax and wool, to a leading place in the industry and commerce not only of England, but of several other countries. Among the great industries of Great Britain the cotton manufacture is king, and its throne is established at Manchester. Other large towns in Lancashire, Yorkshire, Cheshire, &c., are extensively engaged in the manufacture, but they can be regarded only as vassals, toiling for, and rendering homage to, the city on the Irwell. In this work, then, we must give some account of

Manchester in the light of the progress it has made under the influence of the cotton manufacture.

From the earliest years of its existence as a place of any note, Manchester appears to have been identified with the industry and commerce of the kingdom. Leaving aside more remote evidences of this fact, we find it stated in a description of the sister towns of Manchester and Salford, drawn up in the year 1650, that the people were then the most industrious in the north of England. Manchester was, at that time, surrounded by fortifications, which were not dismantled till two years later. The town was a mile in length, and the streets were open and well kept, and the buildings good. The trade was said to be "not inferior to that of many cities in the kingdom, chiefly consisting in woollen friezes, fustians, sackcloths, mingled stuffs, caps, inkles, tapes, points, &c., whereby not only the better sort of men are employed, but also the very children by their own labour can maintain themselves. There are, besides, all kinds of foreign merchandise brought and returned by the merchants of the town, amounting to the sum of many thousands of pounds weekly." The varieties of fustians made, we are further told, were "herring-bones, pillow for pockets and outside wear, strong cotton ribs and barragon, broad-raced thicksets and tufts, dyed, with whited diapers, striped dimities, and lining jeans." The towns of Bolton and Leigh were also engaged in this branch of manufacture. Mr. Humphrey Cheetham, the founder of the Blue-coat Hospital at Manchester, was the principal buyer of cotton goods at the time.

Though some writers of the seventeenth and eighteenth centuries give glowing accounts of the extent and development of the cotton manufacture in Manchester and neighbouring towns, there can be no doubt that the business was carried on only to an extent which, in view of the dimensions it subsequently attained, must be regarded as quite insignificant. The following statement of the entire quantity of cotton wool imported into the kingdom in the years named, and of the value of the cotton goods exported copied from the books of the Custom House, shows this in a striking manner:—

Years.	Cotton Wool Imported.	Cotton Goods Exported.
1697	1,976,359 lbs.	£5,915
1701	1,985,868 „	23,253
1710	715,008 „	5,698
1720	1,972,805 „	16,200
1730	1,545,472 „	13,524
1741	1,645,031 „	20,709
1751	2,976,610 „	45,986
1764	3,870,392 „	200,354

One of the chief obstacles to the earlier extension of the cotton manufacture was the want of spinning machinery. The hand spinners who devoted themselves to the production of cotton yarns were unable to meet the demands made upon them, and weavers lost much time in procuring yarn sufficient for the webs they were commissioned to make. How this difficulty was got over we have already seen in recording the history of the brilliant inventions of preparing, spinning, and weaving machines. No sooner were these appliances brought to a degree of perfection than the cotton manufacture advanced by bounds until it attained the position of the greatest of our industries. Manchester played a worthy part in the grand progress, and has ever since been reaping her reward. No doubt the enterprise of the people has all along been ably seconded by the natural advantages which have surrounded them. Of these advantages, as bearing on the cotton manufacture, Mr. Baines gives us an enumeration which we may reproduce here. He says:—"Three things may be regarded as of primary importance for the successful prosecution of manufactures, namely, water-power, fuel, and iron. Wherever these exist in combination, and where they are abundant and cheap, machinery may be manufactured and put in motion at small cost; and most of the processes of making and finishing cloth, whether chemical or mechanical, depending, as they do, mainly on the two great agents of water and heat, may likewise be performed with advantage. The tract lying between the Ribble and the Mersey is surrounded on the east and north by high ranges of hills, and has also hills of some magnitude in the Hundreds of Blackburn and Salford; owing to which cause the district is intersected by a great number of streams, which descend rapidly from their sources towards the level tract in the west. In the early part of their course these streams and streamlets furnish water-power adequate enough to turn many hundred mills; they afford the element of water indispensable for scouring, bleaching, printing, dyeing, and other processes of manufacture; and when collected in their larger channels, or employed to feed canals, they supply a superior inland navigation so important for the transit of raw materials and merchandise. Not less important for manufacture than the copious supply of good water, is the great abundance of coal found in the same district. Beds of this invaluable mineral lie beneath almost the whole surface of Blackburn and Salford Hundreds, and run into West Derby, to within a few miles of Liverpool.

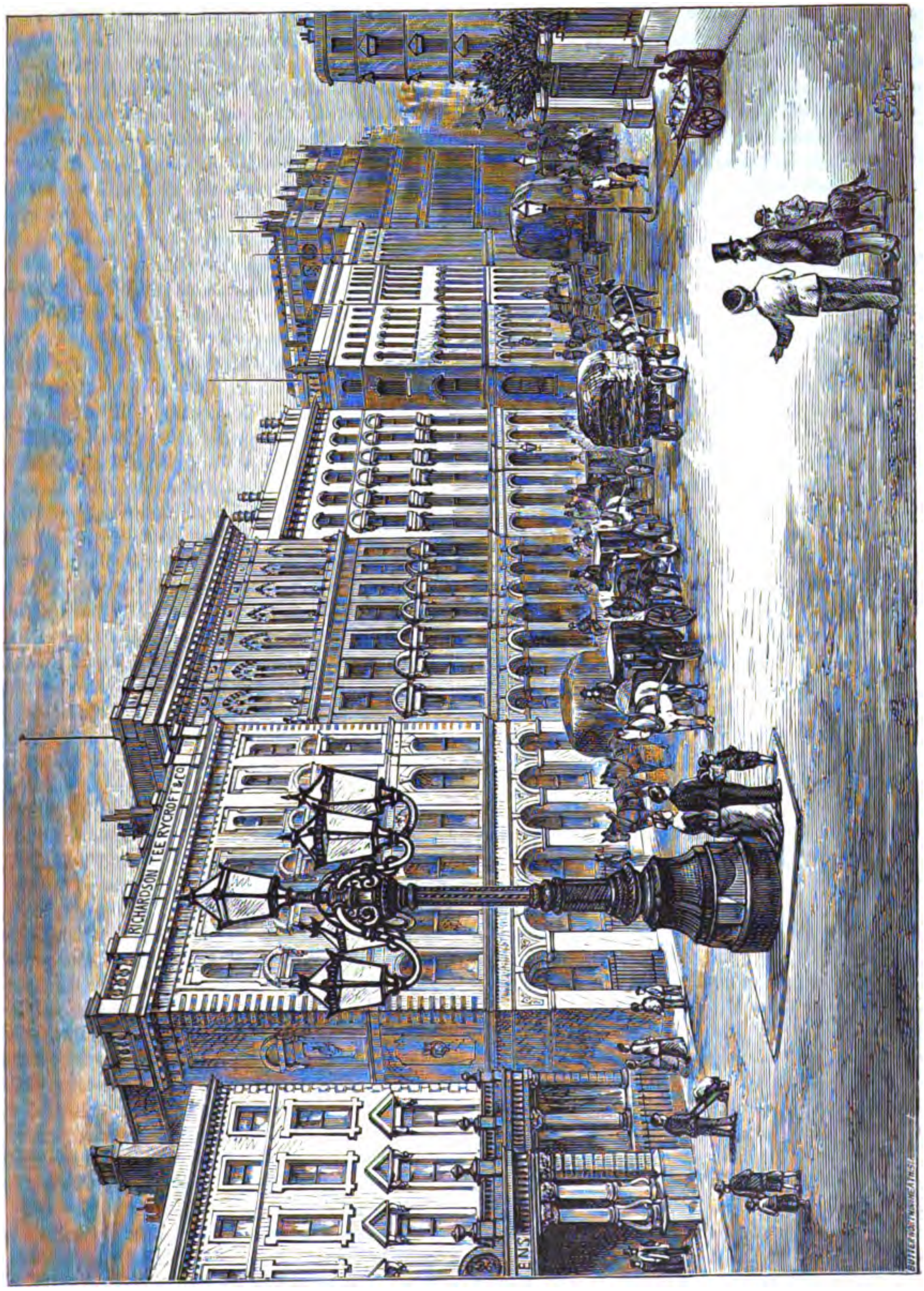
Of the equally indispensable metal, iron, the southern part of Lancashire is nearly destitute; but being at no great distance from the iron districts of Staffordshire, Warwickshire, Yorkshire, Furness, and Wales, with all of which it has ready communication by internal or coasting navigation, it is as abundantly and almost as cheaply supplied with this material, as if the iron was got within its own boundaries."

Writing in 1795, Dr. Aikin in his "Country Round Manchester," divides the trade of the town into four periods:—"The first is that when the manufacturers worked hard merely for a livelihood, without having accumulated any capital. The second is that when they had begun to acquire little fortunes, but worked as hard, and lived in as plain a manner as before, increasing their fortunes as well by economy as by moderate gains. The third is that when luxury began to appear, and trade was pushed by sending out riders for orders to every market town in the kingdom. The fourth is the period in which expense and luxury had made a great progress, and was supported by a trade extended by means of riders and factors through every part of Europe." To this enumeration we shall have to add the period marked by the general introduction of machinery and steam-power, and the facilities for transport afforded by railways. As an illustration of the severe toil to which the Manchester manufacturers subjected themselves, and those about them, we are told that it was customary for the master, with the members of his family who assisted him, and his apprentices, to begin work at six o'clock in the morning. At seven they breakfasted on oatmeal porridge and milk, there being only one dish used for each component part of the meal, and into these all dipped their spoons in common. The other meals were equally frugal, and as soon as they were eaten work was resumed. All apprentices had to pay a premium, and sons of well-to-do farmers and others in the country adjacent were indentured to Manchester manufacturers. In 1695, the premium exacted was about £60, but fifty or sixty years later it rose to £250, and in some cases to double that amount. The apprentices were not pampered by their masters, and as no means were provided for their recreation during the brief periods of leisure afforded them in the evenings, numbers of them resorted to the taverns. It was difficult to get many of them to remain the full term of seven years, service at sea or in the army being considered preferable to work at the cotton business. About the year 1720, the town could boast of "an evening club of the most opulent manufacturers, at which the expenses of each person were fixed at fourpence-halfpenny—viz., fourpence for ale, and a halfpenny for tobacco." Some years later, the usual libation was sixpence worth of punch and a liberal allowance of tobacco. The proprietor of the house patronised by the better class of people closed his doors at eight o'clock, so that his customers must have been men of early habits. Sobriety was highly essential to safety after nightfall, as the streets were paved only in some parts, and for economical reasons the oil lamps were frequently not lighted.

In the rural districts around Manchester there were numbers of small farmers, who cultivated patches of land mainly for their own sustenance, and who found it necessary to engage in some secondary occupation in order to raise the means with which to pay their rents. In the year 1770, cottage rents, we are told, were from one and a half to two guineas per annum, and that included a bit of garden ground and a loom shop or shed. The father of a family could earn from eight shillings to a guinea per week at his loom, and if he had two or three sons capable of assisting, they would bring in an additional eight or ten shillings. Of the condition of business in Manchester about 1760, Mr. Guest, in his "Compendious History of the Cotton Manufacture," says:—"The Manchester merchants began also to export fustians in considerable quantities to Italy, Germany, and the North American colonies, and the cotton manufacture [of linen warp, be it remembered, in combination with cotton weft] continued to increase until the spinners were unable to supply the weavers with weft. Those weavers whose families could not furnish the necessary supply of weft had their spinning done by their neighbours, and were obliged to pay more for the spinning than the price allowed by their masters."

The secrets of the cotton manufacture were jealously guarded by the Manchester people, and their position in that respect was greatly strengthened by an Act passed in 1782. Under this Act a German named Baden was tried at Lancaster, in 1785, and fined £500, for having seduced a number of Manchester cotton operatives to Germany. A man who, in the following year, was discovered to have in his possession a quantity of cotton machinery, which he intended to send to Germany, was convicted and fined £200.

Towards the close of last century, under the



Portland Street, Manchester.

influence of the inventions of Arkwright and others, the cotton manufacture made rapid progress in Manchester and other parts of Lancashire, and has, notwithstanding various periods of depression, continued to advance till the present time. The statistics of the trade were rather incomplete, until returns began to be made under the Factory Act. In 1836 there were engaged in the cotton mills situated in the parish of Manchester, 24,447 males, and 29,210 females—total, 53,657. At the same time the silk manufacture of the parish gave employment to 4,000 persons. Of the progress of Manchester, and the condition of its working population during the years from 1836 to 1857, Sir Thomas Bazley supplied the following account:—

"From that time (1836) to the present (1857), a remarkable steadiness in trade and commerce has prevailed, though distinguished by a most extraordinary increase in production, and consequently by greatly extended business ramifications. The repeal of the Corn Laws in 1846 gave an impulse to the cotton trade beyond all previous experience. Employment has since been uniform and abundant. Wages have not been reduced, but on the contrary the earnings of workpeople have been generally increased, and especially by the constant and unfluctuating employment afforded them. Bread has been moderately cheap; sugar, tea, coffee, and other necessaries and luxuries have been abundant, and sold at prices so reasonable that their consumption has vastly extended. The general comforts of the labouring classes have, during the last ten years, been fully equal to any aggregate enjoyment ever previously experienced by them. In factories the hours of labour are by Acts of Parliament essentially restricted to sixty per week. Wages are now, in the cotton trade, paid very extensively on Fridays, to enable the workers and their families to expend their earnings conveniently and judiciously. With the progress, therefore, of the industry of Manchester, opportunities are afforded to the superior and working classes for recreative amusements, whereby their physical health may be invigorated, and by the increase of libraries and instructive institutions, their mental faculties may be improved and developed."

This is not the place to speak of Manchester as a great centre of political life; but we may allude to its Chamber of Commerce, which is one of the most prominent and influential mercantile bodies in the world. The Chamber was founded in 1820, and from its commencement has been the sworn foe of monopolies. "It was," says Sir Thomas Bazley, "the first public body to repudiate protection for manufacturers—to call for the abolition of every species of differential duties, and for the repeal of the Navigation Laws. All questions, however, of a purely political complexion are strictly forbidden to be entertained, either at the meetings of the Board of Directors, or at a general meeting of the members. The steady and firm course which it has pursued has earned for it a respect and consideration not surpassed—probably not equalled—by any similar association in existence. Its proceedings attract attention in every commercial community throughout the world."

But without tracing the growth of the city and its institutions more minutely, let us glance at the Manchester of to-day. Taken independently of Salford, its population is only 393,585 which places it fourth in rank after London. As already remarked, however, we must in reckoning its wealth and influence, take into account those towns lying round its skirts in which its manufacturers have established their mills. If we do this, we shall find that Manchester is the centre of a population far exceeding that of Glasgow and Liverpool taken together. The corporation has long been distinguished for its activity and liberal-minded regard for the interests of the community, and the affairs of no city in the kingdom are better administered. It is with justifiable pride that the inhabitants speak of their Town Hall, free libraries, public parks, Owens College, and Grammar School; and of the fact that they have their water and gas supplies independently of any speculating organisation. At no period of its history could the town have had any pretensions to beauty. The site forbids that. But during the last fifteen or twenty years the business part of it has undergone radical changes. Many acres of small dwellings and factories of earlier construction have been swept away, and in their stead have been constructed fine wide streets, lined with warehouses of large dimensions, and vying with each other in architectural enrichment. In the centre of the town one may walk for miles between rows of these stately edifices. Ground is now very valuable in that quarter, and some of the by-streets are rather narrow, but that has not deterred the builders of warehouses therein from giving expression to their wealth in stone and lime.

When trade is brisk, the roadways adjoining the warehouses are lined with wagons in process of being laden or unladen, and men are busy all day throwing bundles of piece goods and yarn into the

buildings, or removing bales packed ready for shipment. The pieces are delivered from the mills, bleach works, or print works, in slightly-tied bundles without covering, and the yarn in packages wrapped in brown paper. This arrangement admits of convenient handling and assortment. The warehouses have, of course, been built by private enterprise; but some parts of the town have been, and others are being, rendered more wholesome and sightly than formerly by the corporation, who are working out a gigantic and costly improvement scheme. A narrow and irregular street known as Deansgate has, under this scheme, been opened out into a wide thoroughfare, in which are situated many of the best retail establishments in the city.

The visitor to Manchester who desires to make himself acquainted with the business habits of the people, and to witness the operations of their great industry, will naturally desire to gain admission to a cotton mill, a printwork, the Exchange, and some of the warehouses. We have already described what would come under his observation in a mill and printwork, and we shall now escort him to the Exchange.

The present Exchange building is a testimony to the growth of Manchester's business; for since the first Exchange—built by Sir Oswald Mosley in 1729—was abandoned as being too small, no fewer than four progressively larger buildings have been reared on or near the same site. In 1849 an Exchange was built which long had the reputation of being the largest covered space used for exchange purposes in the world, and it was regarded as ample to meet any future extension of business. About twenty years later, however, it was generally pronounced to be too small, and arrangements were made for the erection of the present gigantic building, at a cost of over half a million of money. The business apartment is a noble hall flanked by aisles, and principally lighted by three great domes on the roof.

Tuesdays and Fridays are the market days, and for an hour or two on these the Exchange is thronged by merchants, agents, and clerks. At noon it is "High 'Change," and that is the time when the scene presented will most interest the visitor. The pillars of the hall are numbered, and merchants or agents are always to be found near the pillar which they give as their Exchange address. Frequenters of the building have, therefore, no difficulty in finding the representative of any firm they may desire to treat with. Looking down upon the throng from the balcony the first thing that strikes the visitor is the solemn earnestness of those who compose it. There is no jovial greeting, no joke-making, scarcely a smile on any countenance. A hum of voices speaking in an undertone pervades the building, and the men who stand in groups of twos or threes, or more, accompany their whispers with nods, winks, and shrugs, which seem to play an important part in the conduct of transactions. Every brain seems to be at work calculating terms, and weighing the chances of profit, and while every man is trying to bring the biggest share of advantage to his own side, he is scrupulously careful to prevent any person but the one he is dealing with from knowing what he is doing. Hence the concentration of thought and the grave aspect of the assembly, which impresses one with the idea that business has been raised into something like an act of religion. Plodding caution is the policy that guides the majority of the assembly, and it is on that that most of the large fortunes in Lancashire have been raised. But there are also present not a few speculators who play boldly, if not always successfully. There is much in the traditions of the Exchange to tempt the latter, no doubt, and the names might be mentioned of men who have, by performing at a happy moment what seemed to be a daring action, realised fortunes. The language of business on 'Change is highly laconic—a dozen words sufficing sometimes to carry through a transaction involving as many thousands of pounds. Having completed a sale or purchase in one quarter, the agents flit about to others, and are able to concentrate into an hour a variety of operations which would be impossible were the negotiations of a more wordy character.

Having got over the impression of solemnity, the visitor will note that the men before him, though chiefly and unmistakably of Lancashire origin, have among them a sprinkling of various nationalities, some standing out conspicuously by their attire. Turks, Syrians, Greeks, Japanese, and others are readily recognised; and so are the tall, smartly-dressed Americans, who represent Southern cotton-planters and dry-goods merchants in various parts of the States. The Lancashire men are a study in themselves. Leaving aside the smart young clerks and buyers, who have not yet developed into the typical form, the Lancashire manufacturers and merchants may be described as men who have a thoroughly well-to-do appearance, and who, notwithstanding the grave countenances they wear for the moment, enjoy life. Business over, the spell which

it seemed to cast over them is broken, and if we follow them to their homes or their hotels we shall find small trace of the taciturnity which was displayed on 'Change. A leading characteristic is a close attention to business, when such is required, and nowhere does "the master's eye" do more work than in the mills and warehouses of the cotton manufacturing districts. Home comforts are not neglected, however; and the mansions which lie in the suburbs of Manchester and other towns of the district are replete with those accessories of books and works of art in which the cultured mind takes delight.

It may be interesting to quote here a description of the scene at "High 'Change," written about forty-five years ago by Dr. W. C. Taylor:—"The Exchange is the parliament of the lords of cotton—their legislative assembly—which enacts laws as immutable as those of the Medes and Persians, but, unlike every other parliament in the world, very much is done and very little is said. Nowhere can there be found so practical a comment on the well-known line—

"'Silence that speaks, and eloquence of eyes.'

Transactions of immense extent are conducted by nods, winks, shrugs, or brief phrases, compared to which the laconisms of the ancient Spartans were specimens of tediousness and verbosity. There is a kind of vague tradition, or rather remote recollection, that a man was once seen to gossip on the Exchange; it was mentioned in the terms one would use if he saw a saraband danced in St. Peter's, or harlequin playing his antics at the Old Bailey, &c. &c. &c. The characteristic features of the assembly are talent and intelligence in high working order, and genius and stupidity appear to be equally absent; but if the average of intellect be not very high, it is evident that not a particle of it remains unemployed."

Let us now look into some of the warehouses. Many of these are of great extent, and tower to a height of six or seven storeys. In those devoted to plain cloth and yarns there is not much that is specially interesting to be seen. The basement is occupied by a range of hydraulic presses. On the first floor are the counting and sample rooms, while the upper storeys are piled from floor to ceiling with pieces of cloth or bundles of yarn. Hoists, either internal or external, afford means of raising or lowering the goods. In executing an order, for abroad say, the cloth or yarn is examined, counted, checked, and lowered to the basement, where it is taken in hand by the packers, who form it into bales of convenient size and enclose it in successive layers of paper, tarpaulin, and canvas. The hydraulic presses reduce the bales to the smallest possible bulk, and while still under pressure, bands of hoop-iron are riveted on. The smaller warehouses are not usually furnished with packing apparatus, and that part of the work is transferred to establishments devoted to packing only. Some merchants confine their attention to print goods, and their warehouses differ from those described only in having their contents arranged in a great many different heaps, indicating separate patterns. Among the largest warehouses in the city, however, are those devoted to general drapery and haberdashery. These houses have travellers calling at every town in the kingdom, and buyers who visit all the home and foreign places where certain of the articles they deal in are produced. Cottons, such as sheetings, shirting, dimities, prints, fustians, and velveteens, are, however, the goods which bulk most largely in their returns. There are a number of smallware manufactories in the town, which are chiefly engaged in making tapes, bindings, fringes, gimps, &c., for the larger warehouses. The number of cases and bales received and sent out from the latter establishments in the course of a day in ordinarily busy times is wonderful, and if one cared to read the addresses on any of the wagons *en route* to the railway stations, he would find packages addressed to widely-separated corners of the earth, as well as to towns and villages in all parts of the United Kingdom. To meet the requirements of customers in different countries many varieties of goods are made which are never seen in use in this country; and it is no uncommon thing to find articles of dress, &c., which were made in Manchester, brought as curiosities by travellers and sailors from distant parts of the earth.

As might be supposed, the development of a great industry like the cotton manufacture, in which machinery is so extensively employed, was followed by the starting into existence of engineering and other establishments on a commensurate scale. Accordingly we find in Manchester and neighbouring towns machine-making works which give employment to many hands, and which send forth machines not only for our home factories but for those which have been set up in various European countries, the United States, and India. The engineering branch of business is an extensive one in Manchester, and the names of not a few of the men who are, or have been, connected with it,

have a more than local fame. It will have been noted that many of the important improvements in the appliances of the cotton manufacture and calico printing have originated with Manchester men, and we venture to assume that in no community is the inventive faculty more highly exercised.

Manchester owes a deep obligation for its development to the Bridgewater Canal, and still finds in it a useful servant. The opening of a railway to Liverpool was also a most important event for the cotton manufacture. The fact that the raw cotton arrived at Liverpool and had to be carried thirty or forty miles to the mills was a serious drawback before the modern facilities of transport were available. From time to time grand schemes for rendering the Irwell navigable for large vessels and forming a harbour at Manchester have been brought forward, and the day when the idea will be realised is not distant. There is no serious engineering obstacle in the way, and there is a tract of low-lying ground to the south of the city which could readily be excavated to the extent required to accommodate a fleet of the largest merchantmen. The opposition of Liverpool, and of vested interest in other quarters, has raised considerable difficulties to the project, but these are not insuperable. Even then the Manchester Canal will not excel as a feat of engineering enterprise what the people of Glasgow have done for the Clyde.

Of towns outside Manchester which are engaged in the cotton manufacture, Oldham is the largest, and for some years has enjoyed the reputation of being the chief seat of cotton spinning in the country. The town was for several centuries famed for the hats and caps made in it, and it retained that branch of business till the introduction of silk hats drove the old-fashioned "beaver" out of the market. Cotton spinning and weaving were introduced to some extent at the same time as in the neighbouring towns; but, owing no doubt to the people concentrating attention on this speciality in hats, those branches of business did not make much progress for a considerable time. The population in 1841 numbered 28,077, but during the next thirty years it increased to 113,100, the increase being mainly attributable to the development of the cotton manufacture. The inhabitants now number over 155,000, and the spindles in the cotton mills increased from about one million in 1840 to over nine millions forty years subsequently. A few years ago the co-operative principle, which has been satisfactorily tested for a considerable time in the supply of food and clothing, was applied to cotton spinning in Oldham. The earlier co-operative spinning mills, favoured by the prosperous state of trade at the time, showed such large returns and tempting dividends, that a mania for the creation of co-operative and limited spinning companies set in. Established concerns were bought up, sometimes at fancy prices, and new mills were reared in all directions. The large profits gained by cotton-spinners came as a revelation, and people literally rushed into the new enterprise. Small traders and workmen staked their savings in shares, and the language of Manchester Exchange became the common talk of the people. "Divi" (dividend) was the idol of the hour, and absorbed the attention of all minds, nor did anybody seem to anticipate that the prevailing prosperity of trade would ever receive a check. Evil times were, however, at hand. Reports of overstocked markets and falling prices gave the first note of warning, and timid investors began to doubt the wisdom of their enterprise. After waiting anxiously to see the course affairs would take, many persons sold out with a loss of a large percentage of the money they had invested; others struggled on until all was gone. The experience was a sharp one, and it will require a long run of good trade to put the people of Oldham in possession of the capital they owned when the limited liability craze took possession of them. Many of the mills of Oldham are of imposing dimensions, and some of them have pretensions to architectural beauty. It is not so long since a mill containing 20,000 spindles was reckoned an extensive concern; now, mills with from 70,000 to 80,000 spindles are common. The mills have five or six floors, the rooms on each being from 12 to 15 feet in height. Besides the machines actually employed in preparing and spinning, a modern mill is furnished with many labour-saving appliances, and the means provided for extinguishing fire are as complete as human ingenuity can desire. Everything shows an enormous advance on the mills and mill appointments of forty years ago.

With regard to the cost of spinning cotton at Oldham we quote the following paragraph from a local journal:—"It is generally admitted that the cost of production is as low, if not lower, in Oldham than in any of the great cotton centres of Lancashire. Here economy in labour has been carried to the highest point. Adult labour has been dispensed with to a degree which no other district has yet attained, and yet the workmanship is equal, if not superior, to that of competitors in any other

town. A well-conducted limited company is a model of efficiency and economy, because there are the highest incentives for economy—emulation and public criticism. It is held that no concern is up to the mark which cannot produce 32's at $\frac{1}{32}$d. per hank. 32's is the staple Oldham count, and if yarns are manufactured at this cost, a fair profit may be made when trade is good, or, perhaps, when it is in a somewhat depressed condition. The expense for spinning a pound of 32's cotton is, in wages, 1d., or rather over this amount. (We are now speaking of a well-conducted mill, non-fireproof, with machinery at a reasonable price, say that paid four or five years ago). If a return of 5 per cent. on the entire capital—share and loan capital—be obtained (5 per cent being the lowest minimum at which profits are calculated), 2½ per cent. depreciation on mill plant, and 7½ per cent. depreciation on working plant, with the current repairs, and the loss attendant on the working of the raw material, this gives 2¼d. per lb.; thus making the cost in wages and other expenses 3¼d. for every pound of 32's produced. That is, if raw cotton can be purchased at 6d. per lb., and the yarn can be sold at 9¼d. per lb., there is a return of about 5 per cent. upon the whole of the capital employed."

In addition to the reputation which Oldham enjoys as the chief seat of cotton spinning, it has long been distinguished for the excellence of the cotton-working machines made in it. For over forty years the firm of Platt Brothers and Co. have turned out machines not only for home customers, but for others in various parts of Europe, Asia, and America. The extent of their business may be judged from the fact that in the various departments of their works they employ no fewer than eight thousand "hands." At the Great Exhibition of 1851 the firm came into prominent notice by the fine display of machines they made, and at every subsequent international show their exhibits have been leading attractions in the machinery court. At the Paris Exhibition of 1867 the head of the firm received the rank of Knight of the Legion of Honour.

Of other towns largely engaged in the cotton manufacture we may mention Bolton, Preston, Blackburn, Ashton-under-Lyne, Accrington, Burnley, &c., all of which have contributed to the development of the trade, while each has devoted special attention to one or more branches, and has a market reputation in connection therewith. Many of the larger firms in the trade own from two to six or eight mills, and, by way of example, we may quote the instance of Messrs. Horrockses, Miller, and Co., who have no fewer than twelve mills at Preston, among the machinery in which are 131 spinning mules containing 143,730 spindles, and throstle frames containing 30,000 spindles, and in the weaving department there are nearly four thousand power looms.

WOOL AND WORSTED.—XXII.

NORWICH TRADE AND SPECIALITIES.

By William Gibson.

NORFOLK is undoubtedly the mother county of the wool and worsted trade, for, although the ancient Britons may have had some rude knowledge of making garments from the hair of goats or wool of sheep, though the Romans founded a factory at Winchester, and though the Norman Conqueror was the means of introducing wool-work as a polite occupation for ladies, there can scarcely be any question that the great incursion of Flemings, during the reign of Henry I., was the practical beginning of these great industries upon a national scale. Large numbers of these foreigners settled in Norfolk. The village of Worstead, about twenty miles from the county town, claims to be the first seat of the manufacture; but the trade speedily migrated to Norwich, where there was a guild of wool-staplers in the reign of the second Edward.

Without going into much detail, we find that the sale of stuffs, in the city of Norwich alone, in the time of Henry VIII., was not less than the value of £200,000 per annum, and, according to other authorities, the stockings made during the same reign—these were of course sewn, not woven—amounted to about £60,000 more. The chief articles made at this time, as we gather from an Act passed for the better regulation of the trade, in the fourteenth year of the "Merry Monarch," were worsteds, says, and stamins, and in the two succeeding reigns, there were added to these, russels,

satins, satin reverses, Naples fustians, dornicks, and coverlets. It was during the reign of Elizabeth, however, that the city commerce advanced by "leaps and bounds." During the days of the Virgin Queen, the Protestant refugees settled in the eastern city, and brought with them the knowledge of new fabrics, and processes for improving the texture of those already in existence. Among the novelties may be mentioned bays, arras, mockades, bombazine, currelles, caungeantries, and all kinds of striped and flowered goods, in silk, satin, and linen mixtures; and it is these ingenious handicraftsmen who must be credited with the introduction of printed goods. Hyde, Lord Clarendon, among others, had a set of Norwich bed furniture in fine wool, printed, which was much admired at the time. In 1582 there were 1,128 men, 1,358 women, and 815 children born before the settlement of the foreign contingent in Norwich, while 1,378 were born after the arrival of the parents in England—in all, 4,679 souls from the Netherlands. As might be anticipated, this large influx of strangers was not looked upon too kindly by the natives, and there were frequent displays of ill-feeling for years; but at length the foreigners were assigned their own quarter in the town and their own place of worship; their own wardens were appointed; and they kept themselves very much aloof from the somewhat jealous townsfolk. But in the lapse of years this soreness gradually disappeared: the foreigners were found to be quiet citizens, good workmen, sharp men of business, and excellent friends. The new flowers which they introduced and grew in perfection — tulips, carnations, gillyflowers, and others—marked the horticultural instincts of the Dutch, and caused the place to be called "The City of Gardens."

Between the reigns of Elizabeth and George I. the woollen trade of Norwich had many ups and downs. During the Parliamentary wars, especially, things were at a low ebb, and bitter disputes, as to value, quality, length of piece, and rate of duty payable to the national exchequer, were frequent. Somewhere about the close of the seventeenth century, the Weavers' Hall was built, and thither all goods had to be taken for measurement, examination of quality, fixing of price, and other matters; and when the Hanoverian monarch came to the throne, the rights of citizenship and the municipal offices were thrown open alike to the Saxons *pur sang*, and the descendants of the Dutch and Walloons, who had long been English in all but name. From this time forward, disputes ceased, trade flourished, and the various manufactures improved in quality.

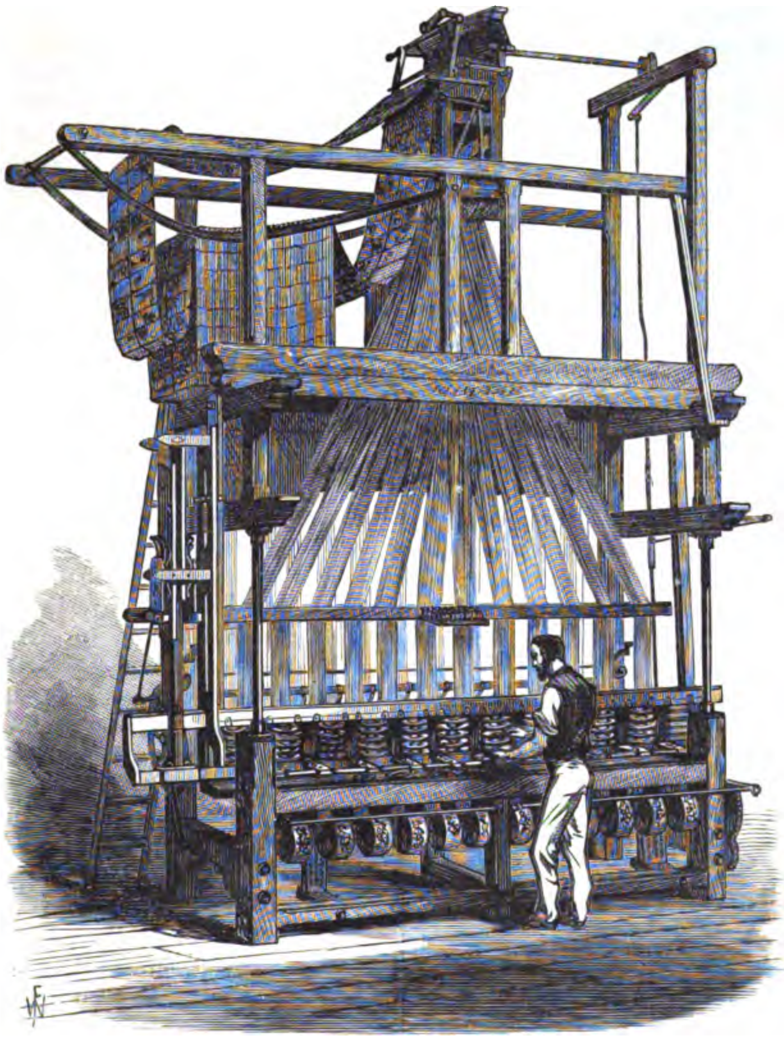
It was, however, by the revocation of the Edict of Nantes that Norwich most largely benefited. This took place, as we know, in 1685, and from that time the city became famous for its crapes, and other light tissues, just as it had previously been noted for its heavier fabrics; and to the French workmen is due not only the improvement in machinery which, subsequent to their settlement, was soon observable, but the advancement of those branches of industry in which silk admixtures were largely used, as well as new processes of dyeing. The crapes were, from the first, in considerable request, for, under the administration of Sir Robert Walpole, crape was ordered as part of the court mourning. This at once made it fashionable, and from that time it has always been popular in the highest as well as the lowest circles. Women in every village in the county were employed in spinning wool by the ordinary distaff and the spinning-wheel, but as much more yarn was consumed in Norwich than could be spun in the county, the combed wool was sent to Yorkshire, Cambridge, Bradford, and even to Westmoreland. And to show the fineness of thread that could be obtained, it may be mentioned that in the year 1754, a spinner at Dereham produced a hard, even-spun, crape yarn thread, twelve dozens and six skeins long, the total weight of which was only sixteen ounces and two drachms. Between 1743 and 1763 Norwich reached the height of its prosperity as the chief seat of the woollen manufactures. Not only in weaving were the workmen of the Norfolk capital in advance of all England, but goods were sent to that city from all parts to be dyed and finished. There were probably 150,000 persons engaged in the various branches of the trade; there were 12,000 looms in the city; the average value of a piece of stuff was fifty shillings per six lbs., and the total value of the products turned out in the course of the year was not less than £1,200,000; and out of that would be paid in wages for labour, between £600,000 and £700,000. Beginning with the shearer and going up to the labourer who packed the goods for export on board ship, there would not be fewer than fifty persons engaged upon each piece of cloth. And although wages then, compared with weekly earnings now, were small, the workpeople lived well. Dyers, hot pressers, and bombazine dressers had about 15s. per week; the best weavers from 14s. to a guinea. Women spinners could earn nearly as much, and children

from 2s. 6d. to 3s. 6d. Yet a weaver never thought of sitting down to commoner fare on Sundays than is now found on the tables of the well-to-do middle classes. The following is a list of the articles manufactured by one house in Norwich, at the beginning of the reign of George III.: — Single and double camlets, harebines, poplins, calimancoes, tapizadoes, rosettas, Mecklenburgs, crusades, florettes, cordetts, chivrettes, diamantines, esterettes, martiniques, belle-isles, ladines, russalines, taboretts plain and brocaded, blondines, Brussels cord, Dresdens, grenadines, and harlequins. This was the house of James Thompson and Sons, who did a large continental export trade; but the staple products were crapes, camlets, damasks, satins, bays, bombazines, serges, and druggets. Not less than 50,000 tods of long wool from sheep, chiefly of the Lincolnshire breed, were used in Norfolk every year during the quarter of a century of the highest success of its trade.

Norwich having a large trade with the Continent, the breaking out of the Thirty Years' War very materially affected its commerce, and before the close of that disastrous struggle there had sprung up, chiefly in the West Riding of Yorkshire, many centres of industry which competed successfully with the older city. Then mechanical inventions were introduced which were eagerly adopted in Yorkshire, but more sparingly in the eastern county. In Yorkshire between 1770 and 1810 the yearly produce was enormously increasing, and at the latter date it reached the value of £2,300,000. During the first ten years of the century the increase per year could not have been less than £200,000. When these facts are taken into account there is no need to inquire further as to the decline of trade at Norwich, for Yorkshire was then engaged in the manufacture of a similar class of goods. The hope of Norwich—as far as its export trade was concerned—centred in the East India Company, which at this time bought as much as £200,000 worth of camlets yearly. This large quantity of goods the Asiatic Trading Society distributed in all parts of their own dominions, in Tibet and China. In the latter country the Mandarins bought the goods eagerly. But Yorkshire was soon in this field too, and in 1820 the orders to Norwich were a mere fraction of what they had been a few years before. Another cause of depression was the gradual advance in price of the raw material. In 1800 Lincoln wool was obtainable for 23s. a tod (that is, 9½d. per lb.), whereas in 1820 it rose as high as 50s. Add to this the fact that shorter wool, which was considerably cheaper, and which, by the aid of improved machinery, was as capable of being spun into fine numbers, and we arrive at once at the secret of the growing success of Yorkshire at the expense of Norfolk.

During the year 1819 there was a momentary arrest of the decline in Norwich trade, chiefly due to Mr. Francis, who introduced a new kind of crape, technically called "tamet woven," formed of a mixture of silk and wool. Ladies eagerly seized upon the new production, and coloured bombazines went almost entirely out of fashion. These crapes were woven in the grey, and afterwards dyed in colours, and so excellently dressed as to compete in appearance with the best satins. All the silk and worsted weavers in the city were once more hard at work, and it was hoped a new era was about to dawn, but Bradford and Halifax speedily got scent of the secret, and once more Yorkshire ran off with the bulk of the trade. So bad indeed did things become that the authorities of Norwich were appealed to, just as in 1879 the poplin manufacturers of Dublin attempted by official patronage to reanimate that industry in the capital of Ireland. A ball, called the "Norwich Crape Ball," was held, to which no lady was admitted who did not wear a dress of that stuff, but, as may be expected, the relief given was only temporary. However, the spirit of invention and enterprise was anything but daunted, and all sorts of stuff in light materials and various colours were tried with varying results. Lyons crape, French poplin, silk and worsted brilliant, and other novelties were introduced. The Messrs. Oxley also introduced a material called "Canton crape," and in 1832 the famous "challis" stuff—certainly the most elegant mixture of silk and worsted ever seen—was brought out, but although the Norwich weavers had again a chance of restoring trade, their habitual haughtiness interposed. Indeed, it may be said in one word that there was enterprise enough among the merchants, inventiveness enough among the pattern designers, taste enough among manufacturers, and knowledge of the finishing processes to have kept Norwich at the head of the stuff trade; but there was always a disinclination to move with the times in improved machinery, there were always two parties in the town so opposed to each other that neither dared introduce improved tools lest the opposite side should break out into riot. Norwich, in fact, was its own worst enemy. The consequence was, that in 1838 there were but

three worsted factories in Norwich driven by steam, and one the motor of which was the antiquated water-wheel, and the total number of hands was under 400. At the same time there were in the West Riding 347 mills employing nearly 30,000 hands. There yet lingered, however, 4,054 hand-loom weavers—1,205 employed on bombazine, 92 on camlets, 20 on camletees, 242 on princettas, 30 on Jacquard looms, 26 on worsted shawls, 1,240 on challis, Yorkshire stuffs, and mousselines de laine, and the rest on bandanas, fillovers, gauzes, silk shawls, &c. The total number of looms in the city, however, was 5,075, leaving 1,021 unemployed. Of those at work 3,398 were in the houses of the weavers, and only 656 in shops and factories, and the average wages of the former were from 12s. 6d. to 26s. per week.



JACQUARD LOOM FOR WEAVING RIBBONS, SCARFS, ETC.

Norwich, however, awoke at length to her true interests, and began, too late for the return of her commercial supremacy, to adopt the methods which modern science and industrial success pointed to as those best calculated to meet the demand for textile fabrics. Machinery of the newest and best type was set up by several eminent manufacturers, the markets at home were partially neglected for that great modern emporium of fine long wool—Australia, and the whole energies of manufacturers became confined to those specialities which had become the staple trade of the town. Spinning factories for the production of yarn were also

erected, and those whose special business it was to dye and finish the goods followed the general tendency among carders, weavers, and spinners. Despite all this the hand-loom weavers of the city and neighbourhood, probably the most expert handicraftsmen in their own department in the kingdom, still obtained the best fancy work, as indeed they do yet, although in diminished numbers.

Among those who have contributed towards the textile prosperity of the city may be mentioned the Norwich Spinning Company, which was built in the parish of St. James's. City manufacturers hired rooms and machinery, and not only spinning, but weaving has long been carried on in the premises, as many as 1,000 hands having been employed at the same time. Messrs. Grout and Co., whose works were erected in Heyham Street, introduced the most approved machinery for the manufacture of silk yarns and gauzes for crapes. Messrs. G. Jay and Sons and Messrs. Blake are well-known spinners of mohair and alpaca yarns, although in this department the Bradford spinners do a great deal more work. Norwich used to export very large quantities of these yarns to the Continent besides supplying the home manufacturers, and Messrs. Jay received a medal for their exhibits in yarns in the Exhibition of 1862. Messrs. Middleton and Answorth are also very large employers of labour, and are notable for their productions of bareges, paramattas, and plain goods. The introduction of paramatta cloth, now one of the staple products of Norwich, is due, however, to Messrs. Willet and Nephew, who are still among the largest makers of this beautiful material. But the firm engages in all sorts of Norwich textures. They annually turn out large quantities of poplins, plain, figured, and watered, bombazines, bareges, coburgs, camlets, grenadines, llamas, linseys, crapes, challis, and several brocaded articles, including figured and embroidered scarfs. Messrs. Bolingbroke and Co. are noted for poplins of every variety, winseys, and bareges. Messrs. Clabburn, who obtained the gold medal for shawls at the Paris Exhibition, 1855, still continue to produce large quantities of "fillover" shawls, besides most of the stuffs enumerated above, and robes, plain and fancy, in great varieties.

It only now remains for us to examine the more prominent of the novelties manufactured in Norwich and district which are referred to in the preceding pages, and to explain in a general way their composition and appearance. Says were heavy worsted cloths in use between the eleventh and fourteenth centuries for outer garments of a plain uncut surface: latterly, they were made much finer, and had a lustrous face. Serge was a finer and looser material used for curtains, hangings, and other domestic furniture, and either dyed red or black, or printed in patterns. Fustians were a strong, heavy woollen material. Russel, in all probability, was a coarse fabric of a russet hue, and may be a corruption of the latter word. Stammets were, it is said, the same as the modern tamet, and were exceedingly fine in texture and high in price. Velvets were fine cloth with a satiny pile. Caungeantries were a kind of taffeta, the silk warp of one tint and the woof of another, so that when viewed from different points it gave various reflections of colour. Perpetuanas appear to have been a well milled cloth, exceedingly tough, like that subsequently known as "everlastings." The old camlet was of wool, hair, or silk; sometimes the warp silk and wool twisted, and the woof hair. Calimancoes were either plain, striped, or figured with flowers and other devices. Crape, we know, is a light transparent stuff like gauze, single or double, crimped or smooth. Damasks were similar to the goods made at present, but union damask is a modern invention, the use of cotton having been unknown in ancient times to the English manufacturer. The poplins were composed of worsted and silk, as at present. Shalloons were full twilled on both sides and of light material. Tammies were plain, from eighteen to thirty-six inches wide, containing from forty to eighty threads of weft and forty-eight to sixty of warp to a square inch. Norwich camlet was thirty-two inches wide, fifty-five yards to the piece, and weighing about twenty pounds. It was woven in the grey, and afterwards dyed and hot pressed. Moreens were stout heavy cloths, watered and embossed, and used to cover articles of furniture. Bombazines were made with silk warp and worsted weft, the latter being thrown up on the surface; satins and brilliants were woven in various patterns on the draw-loom with a silk face. Challis was like crape, but much finer and softer. Instead of having a glossy surface as the Norwich crape, it had a dull clothy appearance. It was worn plain or figured, and where the ornaments were produced on the loom, not printed, it was magnificent. It was partly silk and partly worsted. The introduction of cotton warp quite revolutionised the stuff-trade, and mousselaines de laine—the French ones were entirely of wool—were made with the cotton warp

As these goods are particularly adapted for printing colours upon, they have always been in brisk demand. Grogram was woven with a thick cotton warp, round which a fine white, yellow, or gold silk thread was wound, and a lustrous weft of black worsted. Most of the other fancy goods at present made are too well known to need particular description.

Among the novelties manufactured in large quantities in Norwich are scarfs, ladies' ties, and other narrow-pattern goods which, though not strictly falling within our province to describe, must be adverted to among the novelties of the "City of Gardens." These articles are sometimes composed of silk, mixtures of silk and cotton, silk and worsted, or cotton and worsted. The engraving on p. 145 will enable the reader at once to detect the difference of the loom used for weaving these goods from the ordinary power-loom which is almost universally employed both for the plain and pattern stuffs already referred to, and the hand-loom which, as we have said, still lingers in the suburbs and neighbouring villages. It will be seen that twelve webs are woven at the same time, and that only a single Jacquard machine is needed. The requisite result is arrived at by repeating that portion of the pattern represented on each card as many times as there are webs mounted in the loom, and the cards, instead of running out on the completion of each pattern, are made up in duplicate sets, fastened in an endless band so as to obviate the trouble of changing at frequent intervals. A considerable length of web is woven at each revolution of the cards. A similar machine to this is now largely used in those places where ribbons are woven.

It may not be out of place to quote the prices of a few of the above articles in 1843. Three-quarter lastings were 29s. to 80s.; camlets, 28s. to 42s.; yard wide shalloons, 18s. to 56s.; union damask, 24s. to 40s.; all worsted damask, 28s. to 54s.; says ranged from 36s. to £5. The total annual value of the Norwich fancy goods at present must be over £1,000,000, and this chiefly from crapes, challis, paramattas, and gauze. As the fashion is continually changing, the demand for other goods continually fluctuates. Sometimes a design may be introduced which has a tremendous run for two or three seasons, and then dies away. And even classes of fancy goods that have become staples increase and diminish in popularity. It is therefore needless to particularise such materials as may have been made for a time, and have now ceased to be asked for, but we believe we have indicated the chief features of the woollen trade of Norwich, in which not less than 15,000 persons are at present engaged. All the villages in the neighbourhood of that picturesque cathedral city swell the total, and many persons in various parts of the country would have to be included in an exhaustive estimate of the numbers who directly derive a livelihood from its trade.

IRON AND STEEL.—XXIII.

BIG GUNS.—THIRD PAPER: PROCESSES OF MANUFACTURE.

By William Dundas Scott-Moncrieff, C.E.

THE conditions which are essential to the safety and efficiency of a big gun having already been explained, it only remains to give a description of how these are practically carried out in the great industry which has its head-quarters at Woolwich. An account of how the work is done will best fall under four headings. They are, first, the appliances necessary to obtain the temperature required for the softening, welding, and preliminary treatment of the materials; second, those necessary for dealing with it, so as to secure the highest capacity for resisting excessive strains in particular directions; third, those contrivances which are needed to manipulate large masses of iron in conveying them from place to place, more especially when heated to a high temperature; and fourth, the processes required for finishing the work of the forge, and rendering the masses of iron practically serviceable for the duties of the field or of the fortress.

As in other branches of the iron trade, the furnace is the method employed for the puddling, heating, and welding of the iron, and those which are made use of at Woolwich do not differ in any essential respect from those which have already been described. Though there has never been any disposition shown by the authorities to look askance upon the more recent improvements of private enterprise, nor yet upon the proposals of inventors, there are reasons why such methods as those of

the modern regenerative furnaces of Siemens,* and other improvements, should not be readily adopted at Woolwich. These reasons are to be discovered in the fact that the scale upon which the work is carried out is not so extensive as to make it by any means certain, that much economy would be effected by the introduction of appliances, which are essentially applicable to works that are conducted with different objects in view. It is not that the Arsenal at Woolwich is in any sense a small establishment, or that the number of the workmen employed is less than in other great establishments connected with the iron trade, but in most of these works the object that is desired is to be able to turn out large quantities of manufactured iron in the form of rails, or plates, or bars, whereas at Woolwich the iron that is made is all consumed upon the establishment. What would be a small amount of plant in a work that supplied outside customers whose demands may amount to thousands of tons in a single order, is nevertheless sufficient for the turning out of malleable iron in the quantities that are necessary for the making of big guns, on which a vast amount of labour, employing great numbers of workmen, is necessary before they are ready to be sent to the proof butts upon their final trials. It follows from this that though the authorities are quite alive to the value of improvements, they have not yet adopted those appliances which are common elsewhere, where the scale upon which they are used justifies the outlay of a large amount of capital; and although everything is very complete and perfect of its kind, the visitor will find that in the puddling department at Woolwich, there is much the same sort of plant that might have been seen some years ago, in the leading establishments of the iron trade depending upon private enterprise for their development, or which may still be seen in the smaller works throughout the kingdom, that have not yet adopted the improvements referred to. The puddling furnace, however, in use in the Royal Gun Factories, is a product of that department, and the invention of Mr. Price, the forge manager. Puddled iron can be produced by it at a considerable saving in fuel, and steel ingots are made from it with the same quickness and facility as from the Martin-Siemens furnace. The methods and designs are novel, and their efficiency has been proved practically over a period of years. A step has been made in one direction, however, which it would be well for other iron-masters to follow, in the adoption of mechanical means for working, or rather assisting to work, the iron in the puddling furnace. Reference has already been made † to the immense exertion which is required on the part of the puddler, more especially when the stage of "balling" has been reached, by the iron in its process of conversion, and any one who sees how much this labour is curtailed in the simple and effective machinery employed at the Arsenal cannot but wish that its adoption had become universal. Among the appliances upon which experiments have been made with more or less success for doing away with the labours of the puddler altogether, and substituting machinery, which in itself would afford the requisite labour, there is one at least which has received the most careful consideration of the authorities at the Arsenal.

But although the puddling process at Woolwich is not characterised by any novelty, and the furnaces used for fagging the scraps of iron are of the type ordinarily employed in forges throughout the country, no one can fail to be struck by the great size and completeness of those which are used for heating the huge coils of the big guns, and raising them to the temperature for welding them in solid masses under the blows of the steam-hammers. Their dimensions are alone sufficient to strike even the professional visitor, who has seen them for the first time, with astonishment, and when the great door of fire-brick, braced and bound together by its massive iron bands, rises and reveals the molten depths within, an impression is conveyed to the mind not only of the energy and ingenuity of those who have subjected such an element to their use, but of their courage as well.

But we must go on to the next part of the subject, which is embraced under the appliances that are necessary for dealing with the iron so as to secure the highest capacity for resisting excessive strains in a particular direction. When the ball of iron, or the faggot of scraps, is taken from the furnace, and subjected to the blows of the steam-hammer, and then allowed to cool, it is impossible to say, with any certainty, what the direction of its greatest strength may be. Every blow which it received must have effected a change in the constitution of its substance, so that its internal structure when it is finally thrown aside and allowed to cool must be a matter of very uncertain guess-work. The first appliance, then, which combines in itself not only the means of reducing the iron to the shape required for further operations, but the

* See Vol. I., pp. 311—2.

† See Vol. I., pp. 188—191.

disposal of its fibres in the direction best suited for withstanding the ultimate strain of the explosion, is the rolling-mill. Here again we find that the Arsenal differs in no essential respect from other first-rate establishments, though it may safely be said that there is no better rolling-mill in existence. One advantage it has over most others, in being provided with facilities for reversing the revolutions of the rolls, by means of an apparatus which has been adopted with the greatest success, and which greatly simplifies the operation. It is the invention of Mr. R. D. Napier, whose name is associated with many improvements in modern machinery, and who found at the Arsenal at Woolwich, the sympathy and assistance which are essential to the success of a new invention. The apparatus is of too complicated a character to admit of a description in these pages; but we cannot pass from the subject without congratulating both Mr. Napier and the authorities upon having been rewarded for their enterprise by the great success of the appliance. The limits that are placed in practice upon the dimensions of a mass of iron which has to be passed through a rolling-mill, depend upon the space between the rolls when they are separated, so as to leave the widest possible room for its reception; and the length of the bar which is produced from the rolling process is not only dependent upon this condition, but also upon the cooling of the iron, which takes place when it has been too long exposed to the action of the atmosphere. From both these causes—the limited capacity of the rolling-mill for receiving the mass, and its tendency to become hardened during the process of rolling—it is impossible to obtain anything approaching to the full length of a completed bar ready for being coiled. The unit of length, as it comes from the rolling-mill cannot be more at the most than twenty or thirty feet, and it therefore becomes necessary to weld a number of them together in order to obtain what is required for the formation of a complete coil. When the iron has been reduced to the proper shape in the rolling-mill, it is removed to another department, and the different lengths are welded together, so as to form, if necessary, a bar that, in the case of an 80-ton gun, is about 200 feet in length, and considerably over a foot square in section. Much care is required in the welding process, and it would no doubt be of great advantage, and would embody the principles of construction explained in the preceding chapter to much greater perfection, if such a bar could be produced directly in the rolling-mill. As this cannot be done, the only course left is to exercise every precaution, so as to ensure, as far as possible, that the bar is homogeneous and continuous in its fibrous structure; and as the blows of the hammer necessary for welding the bars together are made at right angles to their length, there is little doubt that the desired object is, in this manner, to a great extent obtained. When the bar has been completed to the desired length, it is placed in a furnace which stretches from one end of a long workshop to the other, and is not equalled in this respect by any other in the kingdom. The longest furnaces employed in the iron trade are those which are used for preparing the frames of ships for the bending that is necessary to shape them to the form of the vessel; but that which is used at Woolwich for heating the coiled bars of the big guns is more than double the length of the longest of those used in ship-building. As it would be impossible to obtain an equable distribution of heat from one centre of combustion, the firing of the coil furnace takes place at intervals along the length of the bar, and in this way the workmen are enabled to obtain the required temperature throughout.

The coiling of the bars can best be described by comparing it with the winding of a strip of paper round the finger, in which the edges of the paper touch each other throughout, and the result of the process is the formation of a cylinder. The difference between this very simple operation and that which takes place at Woolwich, is that the finger of one hand which forms the centre or mandril in the case of the strip of paper is fixed, and the coil is wound round by the fingers of the other hand, whereas at Woolwich the coil is fixed to the centre mandril, which is made to revolve, and in that way to coil the bar round it just as a rope is coiled round the barrel of a windlass. The bar having been rapidly drawn out of the furnace when it has been sufficiently heated to render it soft and pliable, is borne up at intervals upon portable supports provided with rollers on which the bar rests, and which render it easier for the workmen to move it backwards and forwards in the direction of its length. As the power required for this operation is very considerable, even when the friction to be overcome has been reduced by means of the rollers on which the bar is resting, a chain is made fast to the end which projects from the furnace, and this being attached to a sort of winch, in connection with a revolving shaft of the workshop, provides a ready means for removing the coil. When the mandril, or centre round which the red-

hot coil is twisted, is set in motion, much care and skill is required on the part of the workmen to insure its being wound round so as to leave as little space as possible between the edges, but practice has made perfect in this department, as well as in others where the technical difficulties are even greater, and the result of the operation is so complete that nothing further is required than a welding heat, and a few blows of the great steam-hammer to convert the long unwieldy bar as it came from the coil furnace into a solid cylinder, which is practically homogeneous throughout, and having its fibres arranged in the direction best suited to resist excessive strains. There is one respect in which the coiling machine differs from other appliances of a somewhat similar description, such as rolling-mills, and this arises from the necessity for removing the coil, and detaching it from the mandril upon which it has been wound. This can only be done by withdrawing it, and provision has therefore to be made for removing one of the side framings in which the mandril revolves. When this has been effected, the coil is then free to be drawn away to one side, leaving the mandril behind. No such appliance is necessary in the case of the rolling-mill, where the bars or plates or rails go in at one side and out at the other.

The reader will now be able to understand that although the process we have just described is the one of all others that would recommend itself to a practical mechanic, on account of its simplicity and the efficient manner in which it attains the object in view, it also meets the requirements which are referred to under the second heading into which the subject has been divided. The pressure of the coiling-machine is exercised to a great extent in the same direction as that which is exerted by the rolling-mill, and of the many ways in which malleable iron can be and is welded together into large masses, this is pre-eminently the one which combines economy, solidity, and strength in the direction required to resist excessive strains.

When the coil has been completed and allowed to cool, it takes its turn with others which have been previously constructed to go to the great steam-hammer. It is conveyed by rail from one part of the works to the other, and now having acquired great dimensions and weight, presents an appearance altogether different from anything to be seen in the earlier stages of its development. It is now that a new set of difficulties present themselves, in consequence of this excessive unwieldiness. The removal from one department to another when cold, is a comparatively simple operation, as any one can understand who is acquainted with the every-day appliances of cranes and trucks; but when the mass is raised to a white heat, the obstacles to safe and rapid transit are enormously increased. Among the many masterly mechanical details that have been necessary to the development of Mr. Fraser's system, there is perhaps none in which greater or more justifiable pride may be taken than in those appliances which come under our third heading. Although the furnace, to which we have already referred, in which the coils are heated is necessarily of great dimensions, and is made correspondingly strong, yet being constructed of brick-work, it would soon be brought to pieces by the accidental blows of large masses of iron as they were being placed in its recesses or removed from its doorway. And yet of all the appliances, the one that has been adopted is by no means that which would have recommended itself at first sight. A pair of tongs is more associated with the domestic hearth or the blacksmith's anvil than with any idea of capacity for dealing with the weight of many tons. In the ordinary operations of the forge, they are seldom used upon a large scale, the masses of iron in these cases being generally welded upon a shaft that serves to convey them from the furnace to the hammer, and yet not only are tongs the apparatus which has been adopted at Woolwich, but any one who sees them at work would find it difficult to suggest more efficient or simpler tools. But there are tongs and tongs, and as those at Woolwich are sixty or seventy feet in length, and twenty-five tons in weight, the reader must extend his notions of the ordinary pattern before he can form an idea of what they are. The advantages that were offered by the adoption of these appliances are so far apparent. By being suspended towards the middle from the chains of a steam crane, an apparatus was at once provided, not only for passing into the recess of a furnace, but also for placing a mass of iron upon the anvil of a steam-hammer without coming into contact with its framing. Both conditions were of the nature of necessities, and as a pair of tongs embraced them both, it is not so wonderful after all that they should have been preferred to more elaborate contrivances. Like other tongs, these mammoths consist of two limbs and a joint or hinge upon which they move, and which renders them capable of adjustment so as to embrace objects of different size. The manner in which the coil is clinched or grasped after the tongs are placed in a

suitable position for doing so, is the familiar appliance of a screw placed towards the opposite extremity of the limbs. In order to enable the workmen to slew the heated coil backwards and forwards and round in the direction of the steam-hammer, a large counterweight is added to balance the weight of the heated mass. This is adjusted in such a way that the additional weight of a few workmen springing upon the extremity of the tongs is sufficient to raise the coil from the bed of the furnace and support it in the same place while being brought to the hammer. There is no operation of the iron trade, not even in the foundry where the metal is in a molten state, that is more impressive to the unaccustomed spectator than the withdrawal of a Woolwich infant coil from the furnace, and there is none that appears to be more easy of accomplishment.

From the description of the coiling process the reader will have no difficulty in understanding that the object of this heating is to weld the coil into a solid mass. As it is necessary that this should be done by pressure exerted upon the top and bottom of the cylinder of the coil by the blow of a steam-hammer, it follows that in this part of the process there is something which must occur inconsistent with the principles that have hitherto been adhered to in the construction of the gun. We refer to pressure in a direction opposite to that which had been given by the rolling-mill, and which, as we have already repeatedly pointed out, is essential to the structure preserving the utmost amount of strength to resist explosion. There is, no doubt, a disadvantage in this detail having to be carried out in the way that it is done at Woolwich; but it is not only questionable if there is any other practical method known to engineers that is capable of performing the operation, but it also becomes evident to any one who has witnessed the process, that the objection can be hardly more than theoretical, and that little or no practical harm can result from it. The heating of the coil is carried out with much care, and the temperature necessary for the ready adhesion and combining of its edges is so perfectly obtained that one cannot but be astonished by the lightness of the blows that are found to be sufficient for the completion of the welding. In relation to the huge dimensions of the mass, they appear to the spectator to be more of the nature of taps than of blows, and it is certain that nothing is added beyond what is barely necessary to attain the object in view. It is certain that any mismanagement or clumsiness in the manipulation which required very heavy blows from the hammer in order to effect the welding, would have an injurious result upon the fibrous structure of the gun; but so much dexterity has been acquired, and the apparatus itself is so handy, that there is no reason why such contingencies should happen, and quite as little reason for supposing that they ever do.

Several pages would be found insufficient to do justice to the other appliances which came under our third heading; but as these are distinguished more for their difference in degree* than in kind, from similar contrivances elsewhere, we must now go on to the last part of the subject, namely, the processes required for finishing the work of the forge, and rendering the masses of iron practically serviceable for the duties of the field or the fortress.

And first, something must be said of the steel tube which forms the internal lining of the gun. This has been adopted, not because it is a necessary factor in the strength of the gun, but because its substance is better suited for withstanding the action of the gunpowder than malleable iron, and also because it affords a more enduring material for the rifling, and for resisting the wear and tear of the shot. It runs the whole length of the interior of the gun, and being a solid mass bored out so as to form a chamber at the breech, provides the means of resisting the explosion in that direction. After it has been finished internally and turned on its outer surface to a diameter that is measured with the utmost exactness, it is tempered by being carefully heated throughout, and then dipped into a well containing oil, where it is allowed to remain for a certain length of time, and then cooled very gradually. After this operation it is in a fit state to become the foundation of the gun. Accordingly, one of the great coils having been bored with a similar nicety to the outside of the tube, is placed in a vertical position, so as to form a receptacle for faggots of wood. These being set on fire afford the means of expanding the coil by the heat, and in this way the bore is sufficiently increased to enable it to be slipped over the steel tube, and also over a slight shoulder or projection with a corresponding recess. When the coil has been cooled it is then found to be shrunk upon the tube

* The great Woolwich crane may be said to differ both in kind and degree from any that have hitherto been employed in this country. It was devised to play an important part in the construction of ordnance far in excess of anything attempted previously, and will probably be the means, along with other gigantic tools, of placing Woolwich decidedly in advance of all its competitors.

with a result that is practically the equivalent of a solid mass. It is in the same manner as this that other coils are embodied with the rest of the structure, and they are so placed that their largest diameter is disposed of in relation to the violence of the explosion, affording a great resistance in the immediate neighbourhood of the charge, and less towards the muzzle of the gun, where the pressure of the gases becomes greatly reduced by their expansion. Practically the turning-lathe is the tool *par excellence* which is used for the manufacture of big guns after their different parts have come from the forge. It is not only by means of these that the different coils are bored and turned, but the same species of tools afford the means of shaping the trunnions and giving the last finish to the gun itself.

Of the rifling it is unnecessary to say that it is a process which, of all others, requires the utmost exactness. It is performed by means of a great shaft, or bar, which has a diameter equal to about half the diameter of the gun, and which is provided with cutting tools that are carried by its means from the muzzle to the neighbourhood of the breech, cutting out the recesses of the rifling as they go. It is necessary that the interior of the gun itself should have been finished with scrupulous exactness before it is placed in the rifling-machine, because its interior surface affords the only support for the rifling-tool, which has to project so far from any outside means of support. A series of rings fit exactly into the bore of the gun, and through these the rifling bar is passed. By an ingenious arrangement of projections upon its surface, as it passes inwards through the bore it takes along with it, at different intervals necessary for its support, one of these rings, which remains in that position until the rifling bar has reached the extremity of its travel. Upon its being withdrawn, it takes these supports along with it one after the other, and is then placed in a position for again re-entering the gun and taking another "cut." The required twist is given by the bar being forced to follow the guidance of an apparatus which is previously adjusted.

There still remains much to be said with regard to details that are somewhat beyond the scope of this chapter. For instance, there is the breech-piece which is screwed into the largest of the coils, so as to form the breech-piece of the gun behind that which is afforded by the solid back of the steel tube. These, like the other parts of the gun, require to be finished and fitted with the greatest exactness, and are of themselves a splendid specimen of the art of turning in iron. Then of the carriage department, we have only to point out the endless variety of patterns, from the light and portable apparatus that is supplied to our field artillery, to the immense structures that are required for the armour-clad war ship, to show how far the subject is beyond the limits of a cursory description.

SHIP BUILDING.—XXV.

MODERN IMPROVEMENTS IN STEAM-SHIP CONSTRUCTION.

IN the two preceding chapters we have sketched the early history and subsequent progress of steam navigation. It now becomes our duty to examine the principal improvements in ship construction, and marine engineering, which have rendered it possible for steamers to undertake successfully the longest ocean voyages. Perhaps the readiest way of introducing this discussion will be to contrast the earliest steamer built for the Atlantic service, with one of the finest vessels now running between Liverpool and New York. The *Great Western* has been well described as the "marvel of the period" (1837), when she was built. She was 212 feet long, 35 feet 4 inches broad, 1,340 tons burden, and weighed 2,300 tons when fully laden. Her hull was built of wood; she was propelled by paddle-wheels; and to give her a mean speed on the voyage of about $8\frac{1}{4}$ to 9 knots per hour, about 480 tons of engines, boilers, and machinery were required. On her first voyage from Bristol to New York, 650 tons of coal were consumed: on her return voyage the consumption was about 400 tons.

As a contrast to the *Great Western* take the White Star Line steamer *Britannic*. She is over 450 feet in length, 45 feet 2 inches broad, has a gross register tonnage of 5,000 tons, and when fully laden weighs nearly 9,000 tons. Her hull is built of iron, she is propelled by a screw, and from June, 1876, to June, 1877, attained an average speed, on eleven voyages between Liverpool and New York, of 15 knots per hour. Her machinery

probably weighs about 1,100 tons; and yet to drive this huge vessel at this enormous speed, only 850 to 900 tons of coal were burned on each voyage. Any one who will carefully compare these particulars for the two ships, will note that the principal points of contrast may be arranged as follows:—1, The great increase in size and weight of the modern steamer, associated with a very much greater ratio of length to breadth; 2, the substitution of iron for wood in the hull; 3, the use of a screw propeller instead of paddles; 4, the adoption of engines which are far more economical in their consumption of coal; 5, the remarkable increase in average speed. Here, indeed, we have summarised the changes and improvements to which attention will be directed in the remarks that follow.

Increase in the size of a ship, within reasonable limits, is a source of economy in working, and of profit to the owner. Take, for example, two steamers similarly formed, one weighing 1,000 tons when fully laden, and the other 8,000 tons. Suppose them to have engines of similar type, and to attain equal speeds in smooth water. Then, with sufficient accuracy for our purpose, it may be said that the ship which is *eight* times as heavy as the other will require engines of only *four* times the power of those in the smaller vessel, and will require only *four* times as much coal. As a consequence, she can carry a much greater weight of cargo in proportion to her total weight. For instance, if the 1,000 ton ship carried 400 tons of cargo, and burnt 100 tons of coal on a voyage, the larger vessel would be able to carry 4,000 tons of cargo over an equal distance at an equal speed, with an expenditure of coal not exceeding 400 tons. Of course, the larger ship would be much more costly to build, and would be more expensive in working, requiring a larger crew, &c.; but her greater earnings would much more than cover this extra expense. Furthermore, the larger ship, under all the conditions of service at sea, would gain upon the smaller, shorter, and lighter vessel, suffering less check to her speed from heavy seas or head winds, and consequently reaching better average results. In thus speaking of increase in size, while forms and proportions remain similar, it will be understood that we are dealing only with a hypothetical case. Increase in size has, as a matter of fact, been accompanied by great changes in form: instead of the six beams in length, which were to be found in the *Great Western*, the *Britannic* had ten beams in her length. These and other changes in form and proportions have tended to diminish the proportionate resistance offered by the water to the passage of modern steamers; and consequently, engines of comparatively moderate power, suffice to give these vessels high speeds. Moreover, great length diminishes pitching and 'scending at sea, which is a considerable advantage to ships like the Atlantic steamers, that proceed on their voyages, despite the heaviest weather, and aim at keeping their reputation for speed and regularity of service. There are not wanting high authorities who assert that the ratio of length to beam has become unreasonably great in recent ships, and could be reduced with advantage; but into these discussions we do not propose to enter here, contenting ourselves with the remark that the changes in proportions made from the earlier models, have, on the whole, been beneficial.

The substitution of iron for wood hulls has favoured both increase in the sizes of ships, and in their proportions of length to beam. In fact, in wood ships the sizes and forms, as well as engine-powers now common, could never have been successfully employed. The superiority of iron to wood as a material for ship-building has been illustrated in previous chapters;* and it is therefore sufficient to say, in passing, that an iron ship can be made stronger, lighter, and more durable than a wood ship, even when the sizes and proportions adopted do not surpass the limits for which wood is adapted. Nor is it necessary to repeat what has already been said, respecting the advantages to be gained by using steel instead of iron.† It may, however, be interesting to state that the various trials made to build wooden sea-going screw steamers of high speed have in all cases proved failures. In the Royal navy, the *Mersey* and *Orlando* were magnificent specimens of the wooden screw-frigate type, 300 feet long, and steaming 13 knots an hour; but they did not possess sufficent strength to withstand the strains of their powerful propelling apparatus. In the United States' Navy it is now generally admitted that the attempt to build the *Wampanoag* class of swift cruisers of wood was ill-advised. And in the merchant service various attempts to build wooden screw-steamers of large size have been equally unsuccessful. It is a suggestive fact that the *Great Britain*, the first Atlantic screw steam-ship, had an iron hull; and that the various steam-ship companies, in passing from paddle-wheel steamers to screws, invariably adopted iron hulls. Some of these companies (like the Cunard, and Peninsular and

* See Vol. I., pp. 147, 181. † See Vol. II., p. 84.

Oriental Companies) continued the use of paddles after adopting iron for the hulls; while others at once embarked in iron hulls and screw propellers. There are many large wooden war-ships with screw propellers still in existence, but these are of moderate speed and proportions; and the same thing holds good of the wooden screw steamers still used in the coasting trade of the United States.

Did space permit, a most interesting narrative might be written of the earlier proposals and experiments with screw-propellers, preceding their practical introduction by Mr. Pettit Smith and Captain Ericsson. Up to the year 1836, the paddle-wheel reigned supreme in steamers, although there had been many patents taken out for other modes of propulsion, including screws and water-jets. In 1835, Mr. Pettit Smith, then a farmer at Hendon, made a model-boat driven by a screw, and on the 31st of May, 1836, he took out a patent, which may be fairly regarded as the first practical embodiment of the principles since generally adopted in screw steamers, although in many particulars his arrangements were crude and have since been greatly improved upon. In November, 1836, a boat driven by a screw was tried successfully on the Paddington canal, and in the following year this little vessel went to Ramsgate, Dover, and Folkestone. Early in 1838 trials were made with her for the information of the Admiralty; and so great was her success, that in 1838—the same year as the *Great Western* paddle-steamer crossed the Atlantic for the first time—the *Archimedes*, a screw steamer of 200 tons, was laid down, the necessary funds being subscribed by an English company. Almost simultaneously another inventor was advancing independently upon parallel lines. Captain Ericsson was by birth a Swede, but had long been resident in England. He was a skilful mechanical engineer, and in that respect had a great advantage over Mr. Smith. Ericsson's form of screw-propeller differed considerably from that of his rival, but it succeeded admirably in the boat built for its trial, and launched in April, 1837. Two or three small vessels were built in this country from Ericsson's designs in 1837–8, but he left England in 1839 and established himself in the United States, where he added to his reputation by successive inventions of the most novel and valuable character.

Immediately after settling in America, Ericsson designed the propelling machinery for the *Princeton*, a screw steam-frigate of 700 tons, which was built in 1842 at Philadelphia; but before that date the English screw-steamer *Archimedes*, with Mr. Smith's propeller, had not merely achieved success in her preliminary trials, but had visited the chief ports of Great Britain, and made a voyage to Oporto. Her success led to the construction of several other mercantile screw-steamers; and the decision to give the *Great Britain* a screw-propeller instead of paddles, was based upon experiments conducted by Mr. I. K. Brunel with the *Archimedes*. This decision was arrived at in October, 1840, and the date should be noted, as it affords evidence of the undoubted lead of English enterprise in the application of the screw-propeller to sea-going ships. Another consequence of the success of the *Archimedes*, was the determination of the Admiralty, acting on the advice of Mr. Brunel, to make trial of the screw-propeller in the *Rattler*, in competition with the *Alecto*, a paddle-steamer of equal size, similar form, and about the same horse-power. Experiments with the *Rattler* began in October, 1843, and were continued until 1845; the results being in every respect in favour of the screw. From that time onward the screw has been gradually gaining upon the paddle-wheel in sea-going vessels; and there has been no difference of opinion as to its superiority for many years past, whether employed in merchant-ships or men-of-war. It is to be regretted that the "Steam Ship Propeller Company," whose enterprise in building the *Archimedes* did so much towards establishing screw-propulsion, sustained the loss of their capital, and derived no benefit from the subsequent general adoption of the screw-propeller. In 1877, it appears that out of a total horse-power (nominal) of about 584,000 in British steamers, nearly *three-fourths* (427,000) were carried in screw-steamers; whereas in 1843 the *Great Britain* stood almost alone as a sea-going screw-steamer. In 1850, Mr. Inman boldly embarked on a similar course, establishing the line of iron screw-steamers which has since become so well known; but the Cunard Company did not commence the use of screws until 1862, and in that same year despatched their finest and fastest paddle-steamer the *Scotia*. Even the *Scotia* had to yield in the competition with screw-steamers; and, having been sold out of the service, she was altered from a paddle to a twin screw-steamer, and fitted for laying submarine telegraph cables. The Peninsular and Oriental Company were not so conservative as the Cunard, and so early as 1852–3, they owned a considerable number of screw-steamers, including the famous *Himalaya*, which did such good service as a transport during

the Crimean War, and was ultimately bought by the Government, still remaining at work after more than a quarter of a century of almost continuous employment. One of the last of the great steamship companies to adopt the screw was the Royal Mail Company, but they definitely abandoned paddle-wheels nearly twenty years ago.

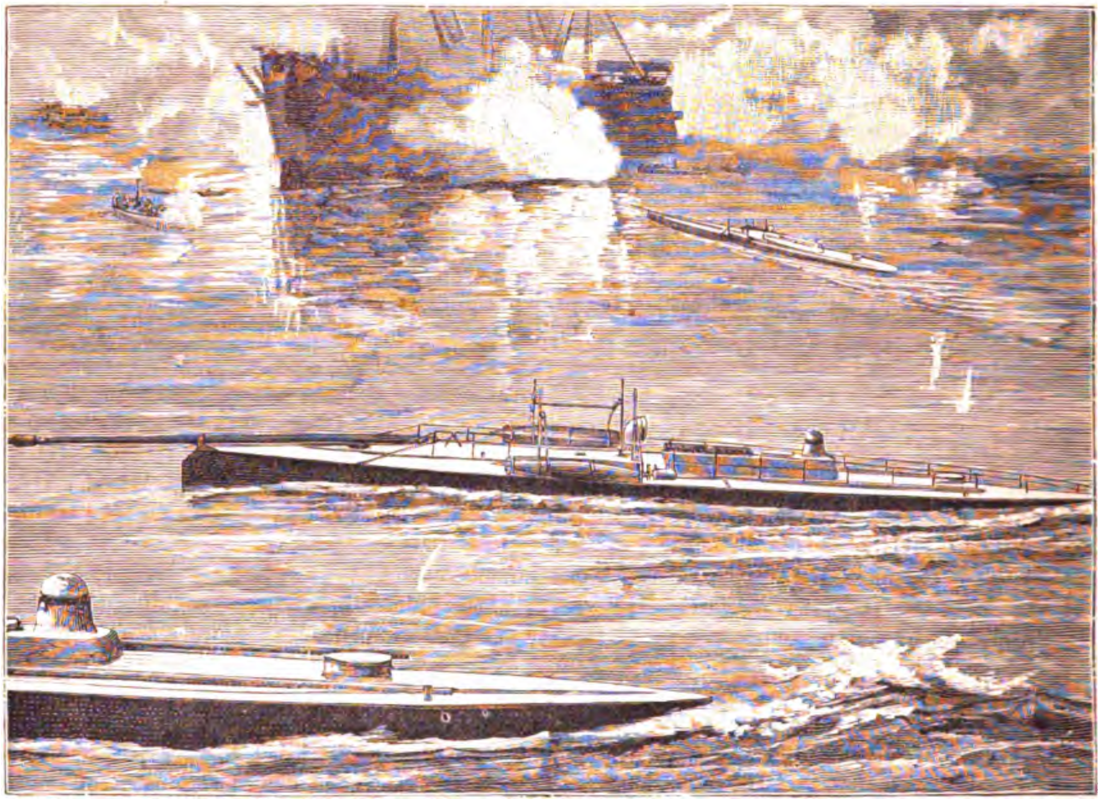
The chief sources of the superiority of screw-propellers as compared with paddle-wheels are easily understood. In making a long voyage, the consumption of coals, provisions, stores, &c., causes a vessel to lighten considerably from the draught at which she floats when fully laden. These unavoidable variations in draught greatly affect the efficiency of paddles, because they suffer both from too great and too small an immersion of the paddle-floats. On the other hand, the efficiency of the screw is not nearly so much affected by changes in draught. Rolling motions also render paddle-wheels intermittent and ineffective in their action, while the screw is scarcely at all affected. Accidents to paddle-wheels from blows of the sea were very common in former times; with screws there are few corresponding accidents. In steaming head to wind or sea, the screw-steamer has an advantage over the paddle-wheel vessel, because it has not the projecting paddle-boxes, &c., which the latter has to carry. Furthermore, the screw is better adapted to working economically at varying speeds than the paddle. For war-ships there is the further advantage that the propeller of the screw-steamer is sheltered by its position under water at the stern of the ship; whereas paddle-wheels are necessarily much exposed. Most commonly a screw-steamer has a single propeller; but in ships of war "twin-screws"—one under each quarter—are now generally adopted, as they prove efficient propellers, assist the manœuvring powers, and are each capable when acting alone of propelling the ships to which they are fitted. In some exceptional vessels, three or four screws have been fitted, and the Russian circular ironclads each had six screws originally, although the number has since been reduced.

Marine engineers have played a most important part in the progress of steam navigation, their energies having been continuously devoted to the production of engines which should possess the requisite strength and durability, but be capable of developing great power in proportion to their weight, and of economising fuel. These objects have been sought in various ways; the chief being the use of higher pressures of steam, greater expansion, surface condensers, superheaters, and different types of engines and boilers. The *Great Western* in 1838 had a steam pressure of 5 lbs. per square inch; at the present time pressures of 60 lbs. to 70 lbs. per square inch are common. In the earlier trans-Atlantic steamers the rate of coal consumption was from 5 lbs. to 6 lbs. of coal per indicated horse-power per hour; at present the corresponding rate of consumption is only from $1\frac{3}{4}$ lbs. to 2 lbs. per indicated horse-power per hour. Formerly, so-called "simple" engines were universally employed, the steam doing its work in a single cylinder on each engine, and escaping from the cylinder to the condenser, where it was condensed by jets of cold water. Now the usual practice is to give to each engine at least two cylinders forming a "compound engine." Into the smaller of these cylinders the high-pressure steam is first admitted; after doing a certain amount of work there the steam escapes into the larger, or "low-pressure" cylinder, where its expansion is completed, and whence it passes to the "surface condenser." This surface condenser contains a great number of tubes surrounded by a casing into and out of which a large quantity of cold water is driven by circulating pumps. The steam is led into the tubes, there condensed, and the water obtained by condensation is again pumped into the boilers. By these and other devices which we cannot attempt to describe, the consumption of coal has been reduced to less than *one-half* of that which was common a quarter of a century ago. Nor need it be assumed that further economies of fuel are impossible, for vessels have been actually worked at a consumption of not much more than *one pound* of coal per indicated horse-power per hour, the pressure of steam employed varying from 150 lbs. to 400 lbs. per square inch. These results have hitherto been obtained in small vessels, and on voyages of moderate length; but they indicate the possibility of further saving in coal consumption, and a consequent extension of usefulness for steam shipping.

In the description of the *Great Eastern*,* we have indicated the remarkable effects produced upon steam-ship design and capability by the adoption of the compound engine, and the consequent economy of fuel. Attention has also been drawn to the more extensive production of coal in various countries, and to the facilities thus afforded for steam-ships to renew their coal supplies at a moderate rate, compared with that which would have

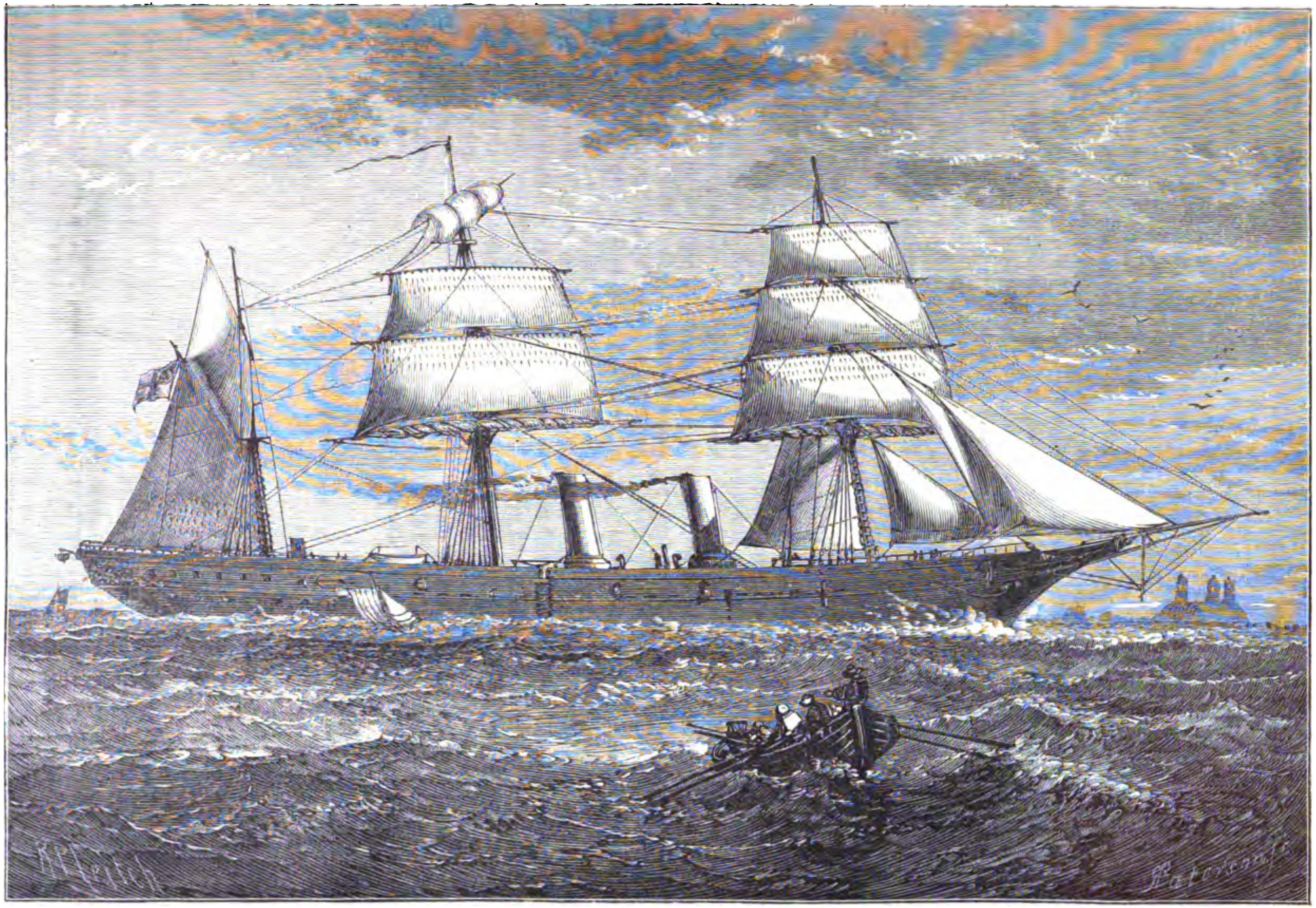
* See Vol. I., pp. 263–8.

to be paid if coal were carried from England to distant depôts. Here it is only necessary to add that the use of large steam colliers has greatly cheapened the cost of transporting coal to the depôts still of the first importance—such as Suez, St. Vincent (Cape de Verde), or the South American ports. Out of the difficulty and cost of the coal supply for the steamers employed by the Pacific Steam Navigation Company on the western coast of South America, thirty-five years ago, arose the desire to develop the use of the compound engine; and the names of Randolph and Elder will always remain associated with this beneficial change. While recognising the important influence which economy in coal consumption has had upon steam navigation, and looking for yet greater economies in future, we cannot refrain from expressing the opinion that the substitution of steel for iron is likely to prove even more advantageous. An iron steamer, such as is now employed on the Australian line, burns about 2,000 tons of coal on the voyage, and carries about 1,200 to 1,500 tons of dead-weight cargo. If she were built of steel instead of iron her dead-weight carrying power would be increased by quite *one-third*, and such a vessel ought to be much more remunerative. To effect an equal saving in coal consumption would necessitate improvements in the machinery, which would reduce the rate of consumption from about 2lbs. per hour to about 1½lbs. Taking a vessel on the trans-Atlantic line, still more striking advantages would result from the use of steel. If the coal consumption were reduced 20 per cent., only about 160 to 180 tons would be added to the dead-weight carried; but the use of steel instead of iron would add about 500 or 600 tons, at least. These figures show that further improvements are well within reach, and that steam navigation has by no means reached its final developments.



TORPEDO BOAT BUILT BY MESSRS. YARROW AND CO.

Lastly, brief allusion must be made to the remarkable increase in the speed of steam-ships that has taken place in the last thirty or forty years. Some facts bearing on this subject were stated in the preceding chapter, but a few additional remarks may be of interest. The original Cunard steamers averaged from eight to nine knots per hour. Under



H.M. DESPATCH VESSEI "IRIS."

the stress of competition with American steamers the speed was increased to ten knots about 1850; soon afterwards it attained twelve knots, and in 1870 was thirteen knots. At the present time, as we have seen, there are other lines of trans-Atlantic steamers averaging from fourteen to fifteen knots per hour, though in particular cases a much higher rate of speed has been attained to. The *City of Berlin*, of the Inman Line, in the period 1875–7 averaged about eight days four hours on the homeward voyages from New York to Queenstown, and eight days twenty-two hours on the outward voyages. Some of the steamers of the White Star Line have traversed a distance approaching 3,000 nautical miles at an average speed of nearly sixteen knots per hour. It is now proposed to attempt the voyage to Australia, some 12,000 miles, at an average mean speed of fourteen knots per hour, which is a knot per hour faster than the average speed attained by the fastest Cunard liners in 1870. And the Cunard Company, expressly in order to meet the severe competition of other trans-Atlantic lines, ordered the *Sahara* to be built on the Clyde, of dimensions and engine-power greater than those of any other merchant steam-ship, except the *Great Eastern*, and of probably as high speed as any existing vessel. These are remarkable results, especially when it is considered that, roughly speaking, the engine power required to drive a ship increases in the ratio of the *cube of the speed*, so that to *double* the speed of a certain vessel her engine-power would require to be increased *eight-fold*, and the amount of coal consumed would be proportionately increased.

What has held good for the mercantile marine has been true also of war ships. Up to 1850 about ten to eleven knots was the maximum speed attained on trial; then by gradual steps speeds of twelve to thirteen knots were reached. When the ironclad reconstruction began in 1859 speeds of fourteen knots were achieved, and from fourteen to fifteen knots is the measured-mile speed of the ironclad battle ships now afloat. Then came the *Inconstant*, which reached 16½ knots on trial, and lastly (in 1878) the *Iris* despatch vessel (of which we give an illustration) reached the extraordinary speed of 18·6 knots per hour on the measured mile. Even this speed has been exceeded, however, by some of the wonderful little torpedo vessels now being extensively adopted in the various war-fleets of Europe. The highest speed yet recorded is that obtained by a boat less than 90 feet long, built by Messrs. Yarrow for the Royal Navy, which attained the speed of nearly twenty-two knots—over twenty-seven miles—per hour.

Very high speeds have also been obtained in some vessels built for special purposes. For example, her Majesty's paddle-yacht *Victoria and Albert* attained nearly seventeen knots per hour; the famous Holyhead packets reached eighteen knots per hour on the measured mile, and averaged over fourteen knots per hour on service during a period of fourteen years. The *Mahroussé* paddle-yacht, built for the Pasha of Egypt some years ago by Messrs. Samuda, exceeded 18¾ knots per hour on the measured mile. Equal speed has been obtained in one or two of the fastest Clyde river-steamers, as well as in American river-steamers. There can be very little doubt but that these figures will probably be surpassed before long; for in spite of warnings and prophesies of possible disaster, the tendency clearly is to the adoption of greater engine power and the attainment of higher speeds.

EMINENT MANUFACTURERS.—VIII.

MARK FIRTH, SHEFFIELD.

By Robert Haig Dunbar.

FEW names are more familiar in the iron and steel-making circles of England than that of the late Mark Firth, who was head of the firm of Firth and Sons, Norfolk Works, Sheffield. His history is a remarkable illustration of what can be accomplished by men who make the most of their opportunities, and know when to seize the fitting time to place their claims in quarters where recognition is most valuable to themselves and to the community in which their lot is cast.

Mark Firth was born at Sheffield in 1819. He was one of a family of seven—five sons and two daughters. Of the sons Mark was the eldest; the second was Thomas, who died in 1858; the third.

John, who died at Malta in 1869; while the two remaining sons, Edward and Charles Henry, entered in partnership along with their brother Mark, constituting the firm of Thomas Firth and Sons. The father of Mr. Mark Firth was a steel-maker, employed originally at "Marshall's"—one of the earliest firms in the Sheffield steel trade. He was subsequently engaged at Messrs. Sanderson Brothers'—now a limited concern, well known the world over—where his singular skill in the production of steel made his services peculiarly valuable. It occurred to the father—so the story goes—after he had been refused some slight advance of wages, that he might do better on his own account. With his two sons, Mark and Thomas, he left Messrs. Sanderson's, and started business in Charlotte Street. This was in 1843.

Perseverance and tact were brought to bear upon the new concern, and the business in Charlotte Street rapidly prospered. They were successful in hitting a time when fortunes were rapidly made in the steel trade; and their brand of steel, and other productions, speedily took a leading place in the home and foreign markets. From the small beginning of Charlotte Street has sprung the immense establishment of Norfolk Works, which forms one of the industrial sights of Sheffield, and ranks among the largest manufacturing concerns in the world. Its principal feature is the refining and manufacture of steel, in which the firm are unrivalled. They have been singularly successful in retaining the secrets of their processes, and there is no place in Sheffield where it is now more difficult to get information as to business matters than at the Norfolk Works. Like other Sheffield manufacturers, Messrs. Firth and Sons have gained wisdom by experience. At one time Sheffield establishments were freely opened to everybody, and the intelligent foreigner, with the sharp-witted American, came pencil and note-book in hand, and wrote down what he pleased. More care is now taken to keep the knowledge that is left. To this day Messrs. Firth retain their special reputation in steel; and they have also a high name for the best brands of foreign iron, of which they are large importers, and in which they deal as merchants. Their wharfs on the Sheffield Canal are a model of order and neatness—the "stacks" of fine foreign iron being piled up as beautifully as if they were designed to remain there for ever, each stack representing some £20,000 or more in value. Among these specialities are steel shot and shell, steel for rifle barrels, and large castings for marine and other engines. They also manufacture files, edge tools, &c. It is as gunmakers, however, that the Messrs. Firth are best known to the world. To speak more accurately, they make steel tubes for guns, the boring being done elsewhere. The firm supply their steel to our own as well as to foreign Governments, principally as war material in the shape of these tubes, and also in the form of shells, and every other purpose offensive as well as defensive. Their steel tubes stand in very high estimation, not only in the official circles of England, but of the principal Powers of Europe, though Krupp has largely interfered with the Sheffield manufacture of big guns. It is not generally known that the whole of the steel employed in the manufacture of guns for the British Government, where steel is used, has been Firth's steel. All the guns are marked in the muzzle "Firth's steel." Any one who has walked through Woolwich Arsenal may find hundreds of the playthings of war stamped with the name of Firth. At their works royal and distinguished persons, with deputations from the learned bodies of England, have witnessed the operations of casting ingots for guns—from the light 6-ton and 9-pounder used for mountain warfare, to the 35-ton and still more mighty 81-ton thunderer. It was at Messrs. Firth's works that the ingots were cast for the 100-ton guns now fitted as the armament of the *Duilio* and *Dandolo*, the monster ironclads of the Italian navy. There were four of these immense pieces of ordnance—two for each ship. The order was entrusted to Sir William Armstrong, of Elswick Works, Newcastle-on-Tyne, who had the ingots cast at the Norfolk Works. The operation was witnessed by a large number of eminent persons, including the representatives of the Home Government and of the leading Powers of Europe.

Messrs. Firth established their works at Saville Street about the year 1849, and they now cover about fifteen acres. They have other works at Whittington, in Derbyshire, which extend to some twenty-two acres; and several forges at Claywheel, near Wadsey. The speciality of their business, as we have noted, is the casting of steel blocks for ordnance and shot, both spherical and elongated—in addition to all kinds of heavy forgings for engineering purposes. They began with gun-blocks of 7 inches diameter, and have gone up to 16 inches—the latter being for the 81-ton gun. These were done in single castings; those for the *Duilio* and *Dandolo*, the 100-ton guns, were done in two castings. The progress of the firm, after their removal from Charlotte Street to Saville Street, was so rapid that in 1869 we find them casting "steel blocks for

guns weighing as much as 14 tons, and measuring from 13 to 15 inches in diameter; spherical shot measuring from 8 to 15 inches, and weighing 500 lb.; and elongated shot, weighing from 200 lb. to 500 lb." At that time they had also cast "14 tons in ingot for a crank shaft for a marine engine, which weighed 9 tons when finished. They were employing 20 steam engines and 16 steam hammers, the heaviest of which weighed 25 tons; and the anvil block on which this hammer strikes is a solid casting of 163 tons of cast-iron." Like other concerns, the period of depression unfavourably affected them; but their works were still the first of the kind in the country. It is a great deal to be able to say, as the firm can say with truth, that they have supplied nearly all the ordnance the British Government has afloat in her ironclads, and a large weight of that of France.

Mr. Firth was remarkably liberal in devoting his means to the benefit of his townspeople. "I determined," he once remarked, "that if it pleased Providence to prosper me in my undertakings, I should devote a large portion of my means to the good of others; and if in what I have done I have succeeded in being of service to those around me, that is sufficient reward; I have had great pleasure in the doing of it." Nobly did he keep to his determination. God prospered him abundantly, and of his abundance he gave freely and munificently. The first great work with which his name will ever be associated was the erection of almshouses, at Hanging Water, Ranmoor, only a short distance from Oakbrook, his residence. They cost £30,000, and were opened in 1870. Earl Shaftesbury laid the foundation-stone. There are thirty-six houses for the accommodation of forty-eight persons, less or more as the occupants may be married or single. A house is provided for the chaplain and governor. Each house for the inmates has a living-room and a bedroom, with larder or coal-cellar, and is supplied with gas and water. The building is in the form of a double quadrangle, the style of architecture being Early Gothic. In the centre stands a chapel, surmounted by a tower and spire in the Early Decorated style, with an arcaded chamber containing a bell, whose soft mellow tones seem to harmonise with the secluded and peaceful characteristics of the situation. The inmates have a free occupancy of the houses, and receive, in addition, a weekly allowance, amounting to 10s. for a married couple, and 7s. for each single inmate. A number of persons who reside outside are supplied with a weekly allowance varying from 2s. 6d. to 5s. The almshouses are under the management of gentlemen of the town, chosen as trustees, in whose name, and those of others who may be elected to succeed them, it is settled "in trust for the benefit of the poor of Sheffield for ever." The almshouses are really intended for those who have seen better days. Mr. Firth's sympathies were peculiarly with those who have failed to make their way in business, or who, from ordinary casualties, have declined in position. These classes he reached by his double scheme of indoor relief and outdoor help.

Mr. Firth was a member of the Sheffield School Board from its commencement, and occupied the position of Vice-President. To this work he gave great attention, bringing to bear upon it the acute sagacity, sound judgment, and tenacity of purpose, which contributed so largely to his remarkable success in his own business. He bore a very prominent part in one great work rising out of the awakened interest in education—the Cambridge University Scheme. Observing how eager the people of Sheffield were to take advantage of this scheme, Mr. Firth promised, that if the movement showed signs of permanent success, he would make provision for the students having Collegiate buildings. The first site thought of, and which indeed was purchased for the purpose, was the ground in West Street, on which the works of Messrs. Sanderson Brothers and Co., Limited, were formerly situated. The site cost £8,000. It would have been a singular fact if the Firth College had been erected there—on the very spot where Mr. Firth himself was employed in his early days. Afterwards, however, the School Board arranged to have a block of buildings in the centre of the town for higher schools and offices, and it was thought advisable to suggest that the Firth College should form part of the scheme. Mr. Firth agreed, and there are now erected a splendid pile of educational institutions, which very few towns can show, and of which the Firth College forms an important and prominent portion. This work cost Mr. Firth at least £20,000, including an endowment of £5,000. An Endowment Fund has also been formed, towards which over £15,000 has been subscribed by generous townsmen, Mr. Firth himself heading the list of subscribers with £5,000.

Firth College was opened on October 20, 1879, by the late Duke of Albany, who visited Sheffield specially for the purpose, and had a most enthusiastic reception. The Prince was the guest of Mr. Firth at his residence, Oakbrook, Ranmoor,

and stayed with him from the 18th to the 22nd of the month. In opening the College, his Royal Highness delivered an address which attracted great attention throughout the country, and was in every way considered worthy of "the student of the Royal Family." In beginning, the Prince said:—"It gives me very great pleasure to be present here to-day on the occasion of the opening of the Firth College, to greet the accomplishment of another benefaction from the same hand which bestowed on the people of Sheffield that park which the Prince of Wales had the pleasant task of opening four years ago. We must all welcome this new proof of Mr. Firth's wise munificence with pleasure, but not with surprise. We cannot wonder that when a man has tasted the happiness of great and generous actions he is eager to enjoy that high delight again, and finds other triumphs and satisfactions insipid as compared with the triumph and satisfaction of conferring on his fellow-townsmen a real and lasting good. And probably the fact of his being a Sheffield man has had no little influence in directing Mr. Firth's mind to the idea of this institution, which will form so important a bridge to connect your primary with your higher education. For there is perhaps no large town in England in which more care has been bestowed on elementary education than in Sheffield; and your central schools, whose façade falls in so well with the buildings of this new college, form one of the best illustrations which England has to show of her boast that, in however low a rank of life an Englishman may be born, his country affords him the means of rising by education to whatever position his talents and character fit him to fill." Speaking of the higher uses of wealth, his Royal Highness said:—"Those men who with great wealth at their disposal elect to spend it in mere sumptuousness and luxury are repaid indeed by admiration from certain persons and of a certain kind. But how far richer is the reward of those who, after spending what is needed to maintain with dignity their place in society, devote the remainder towards furthering the happiness of their fellow-men. Far off generations shall rise up and call such men blessed, and the names they leave behind them shall be ranked with such names as those of Peabody, in London; of Owens, at Manchester; of Mason, at Birmingham; of Firth, at Sheffield."

Prior to the Prince's speech, Mr. Firth stated the objects he had in view in erecting the college. "It is," he said, "to provide in a systematic and permanent form, certain educational means and facilities for promoting the intellectual, moral, and social elevation of the inhabitants of this town. The original design was simply to take up the work of general education at whatever point it had ceased in the School Board Schools, and in our various other institutions, so as to bring, at a small cost, the opportunities of a higher training within the reach of all who might desire to possess them. But since then the design has been enlarged to the comprehension of two other objects; the former of which is to extend the range of instruction, whenever the needful resources for this shall be

available, so as to include a system of technical education for the due qualification of the artisans of the town for the several kinds of trade and manufacture in which they are engaged, and on which the prosperity of the town so much depends; and the latter is to prepare such students as give promise of the requisite proficiency, and who may desire still further to pursue their studies, for matriculation at one of our national Universities, and so, therefore, for whatever other advantages and rewards may attend a complete University training."

Impressed deeply with the want of such a college, Mr. Firth went on to say: "I have thought that I could not more serviceably appropriate a portion of that wealth which, by the blessing of Almighty God I have been privileged to acquire, than by erecting and presenting to my native town the building in which we are now assembled as a local habitation for the college. It has given me very great pleasure to do this." The building comprises lecture hall, class rooms, rooms for lectures, and other needful accommodation, with the necessary fittings for a complete system of higher education. At the head of the college, subject to a council in which its general management is invested, is a Principal, who is reinforced by a staff of eminent Professors. Mr. Firth also founded a chair of chemistry in connection with the college. For this purpose he invested a sum sufficient to secure £150 per annum, which, with the fees received from students, provides the honorarium for the Professor.

In recognition of Mr. Firth's liberality, a testimonial fund, amounting to £2,350, was subscribed. Out of this were secured a bust of Mr. Firth in marble, by Mr. Albert Bruce-Joy, which now adorns the vestibule of the college; and a portrait in oil, by Mr. W. W. Ouless, R.A., which has found a fitting home side by side with the portraits of other local celebrities in the Cutlers' Hall. A cheque for the balance, a sum of £1,500, was handed by his Royal Highness to Mr. Firth, after the ceremony of opening the college. Mr. Firth, in returning his thanks, summed up with characteristic brevity his various works:—"In respect to the several services to my native town referred to in your address, I may say that I was influenced by no other motive than how best to promote its happiness and welfare; nor did I expect any such expressions of appreciation as those contained in this address. When I first considered what course I should take to give effect to my desire, it struck me that I could not do better than make provision for those who from old age or adverse circumstances were unable to provide for themselves. Afterwards it occurred to me as a very proper object, to provide means of pleasurable and healthy recreation for the labouring part of our population by means of a public park, and finally to help forward in some efficient manner the great educational movement which has of late so happily commenced in this country generally, and in this town of Sheffield in particular. I am thankful to have been able to accomplish in any degree these several objects, and trust very sincerely that they will be the means of much service and profit to others, as they are, and will be of great pleasure to me."

Perhaps the public work with which Mr. Firth's name is best known outside Sheffield, is the park which he presented to the town in 1875. It had for years been his intention to make a gift of this kind. Several sites were thought of and abandoned, until at last, disappointed in securing ground at one place on which he was bent, Mr. Firth altered his purpose and determined to erect a home for fatherless and motherless children. One day, however, after his work was done, he noticed an advertisement in a local paper setting forth that Page Hall estate, near Sheffield, was for sale. It struck him at once that here was another opportunity of carrying out his cherished scheme. He sat late the same night turning it over in his mind, and before he went to bed he had decided to bid for the land, and had then settled the sum he thought it worth. Next morning he rode round the estate, and the result was that he added considerably to the estimate he had formed the previous evening. He purchased the estate for £29,000, and the very first thing he did was to set apart thirty-six acres for the use of the people of Sheffield as a public park for ever.

Mr. Firth had the signal honour conferred upon him of being called to the chief magistracy by a single bound. A vacancy occurred on the aldermanic bench, and the Sheffield town council paid Mr. Firth the unprecedented compliment of electing him to the office, inviting him at once to become mayor of his native town. Mr. Firth accepted the office, and during his year of office the Prince and Princess of Wales visited Sheffield and opened the Firth Park—their Royal Highnesses staying two days and two nights at Oakbrook, Mr. Firth's residence. The welcome given to the illustrious visitors was something extraordinary, and the Prince and Princess frequently

expressed their appreciation of the exuberant loyalty with which they were received. Mr. and Mrs. Firth then did their parts with remarkable munificence, worthily sustaining the reputation of Hallamshire for unbounded hospitality. While in Sheffield their Royal Highnesses witnessed the operations of casting ingots for guns, and were greatly interested in the work. Every local honour that could be conferred was conferred on Mr. Firth, including the unique and unparalleled distinction of being appointed Master Cutler for three consecutive terms, while in November, 1879, he was strongly urged to stand for Parliament in succession to Mr. Roebuck. Only a year later (November 28, 1880) he died, amid the great grief of his townsmen. But he lives in their memory as a munificent benefactor and an excellent man.

The portrait of Mr. Firth is taken from a photograph by Mr. William Notman, of Montreal.

HEMP, FLAX, AND JUTE.—XXIII.

A MODEL JUTE-MILL—PROSPECTS OF THE JUTE MANUFACTURE.

By David Bremner, Author of "The Industries of Scotland."

DUNDEE, as we have seen, has the credit of introducing and developing the jute manufacture; and in selecting a jute-mill to describe, we naturally go to that locality. But, apart from such a consideration, the Camperdown Linen Works of Messrs. Cox Brothers have exceptional claims to be regarded as a model establishment. They are situated at Lochee, a village closely adjoining Dundee, and are among the most extensive and complete textile factories to be found in this or any other country. The ancestors of Messrs. Cox were identified with the linen trade of Forfarshire for five or six generations. The present firm was formed in 1841, the members of it then being engaged in the linen manufacture, though they had separately made successful trials of jute. The firm had not been long in existence when attention was concentrated on the new fibre, and the results were so satisfactory that the working of flax was abandoned, and for the last twenty or thirty years jute has been the leading feature of their business.

The Camperdown Linen Works cover twenty-two acres of ground, most conveniently situated, and have been constructed on a regular and well-considered plan. Unlike many factories which have from small beginnings assumed large dimensions, the works display no patchiness of appearance nor agglomeration of blocks of different styles. The ground was laid out so as to admit of any department being extended without interfering with the general convenience of arrangements, which provide for the various processes of manufacture being carried on without waste of time in moving the materials from one department to another. The jute stores, preparing, spinning, bleaching, dyeing, weaving, printing, calendering, and packing departments adjoin each other in convenient succession; and then there are an iron foundry, a brass foundry, and a machine-making shop, for all the machines used in the factory are made and repaired on the premises. The works were constructed between the years 1849 and 1864, and display every improvement for securing the health and comfort of the operatives. The rooms are unusually lofty, and scrupulous cleanliness seems to be the order everywhere. In this respect the factory is in striking contrast to some of the older mills of Dundee and other manufacturing towns, in which light and air seem to have been regarded as pernicious things, which were to have as little accommodation provided for them as possible.

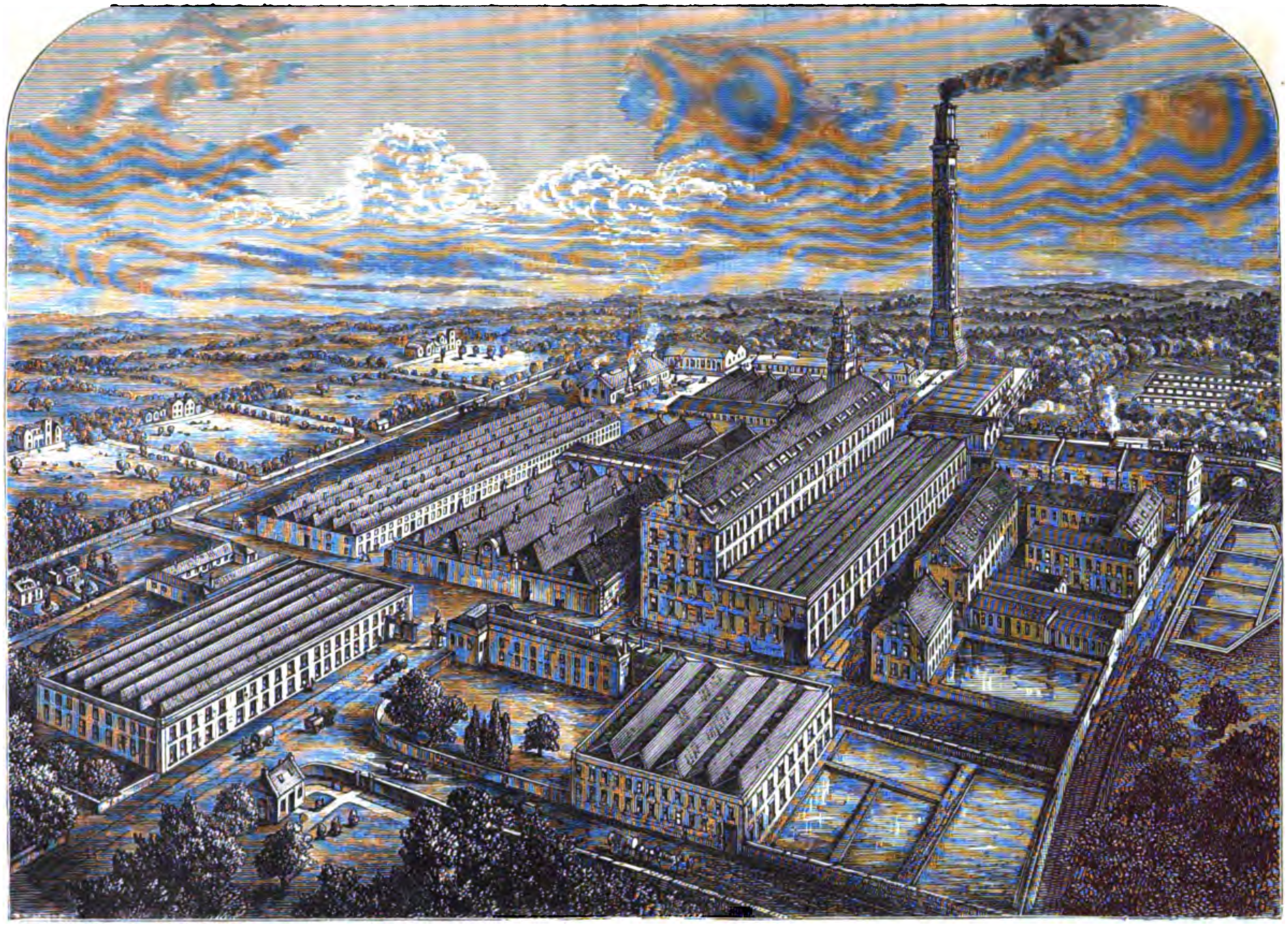
All the raw material is brought in and a large proportion of the finished goods are sent out on a branch railway, which connects the works with the main system. In order to ensure proper treatment of the fibre, Messrs. Cox have a large establishment at Calcutta, in which the jute they purchase is dried, sorted, and packed by hydraulic pressure. This work is done by a numerous staff of natives, under the supervision of Europeans. The jute is carried to Dundee in sailing vessels, and on arriving at the works, is deposited in the stores, which are twelve in number, and are detached from the other departments as a precaution against fire. The stores are equal to accommodating 92,393 bales of jute, weighing in the aggregate 16,499 tons. This enormous quantity of fibre is not largely in excess of what is used up in one year—the exact figures being 86,000 bales, which yield 3,294,000 spindles, or 16,000 tons of yarn. The jute is of

various qualities, according to the purpose to which it is assigned, and the storekeepers take care that the different sorts are kept apart, and supply them as required. When the bales are opened the jute is seen to be arranged in handfuls, or bundles, as it was left in the washing and drying processes in India. It is wiry to the touch, and does not yield kindly to any attempt to twist it with the fingers. This was the quality which gave so much difficulty to the early experimenters with the fibre, and it was not got over until a process known as "batching" was resorted to. Batching has now been abandoned to a large extent, and is not practised at the Camperdown Works; but still we may give a brief description of it. The bales were brought from the store, opened, and their contents taken in small quantities at a time, and shaken out in a stall-like compartment, ten or twelve feet square. As each layer of jute was formed, a jet of water was played over it, then a jet of oil, and, finally, a jet of antiseptic fluid to prevent putrefaction. After lying in batch for four or five days the fibre became pliable, and yielded to the action of the spinning machines.. While in the batch a small measure of acetic fermentation occurred, and if, on the third or fourth day, the hand were thrust among the jute, it would be found to be quite warm; while moistened litmus test paper revealed the presence of free acid. Great care was required in conducting the batching to prevent deterioration of the fibre by heating and dry-rot.

Instead of being batched, the jute is now sent direct to the "mangle," or softening machine. This machine consists of a series of fluted rollers which work into each other, and as they revolve have a slight longitudinal reciprocating motion. The jute is fed into the machine on a table, and just before it enters, a fine spray of water and oil descends upon it. The rubbing and bending action of the rollers impregnates the fibre with the fluid, and renders it soft and pliable. It is now passed to the breaker carding engine, the duty of which is to reduce the jute to fibres of a size suitable for spinning. Jute has not naturally-defined filaments, such as cotton and wool have, and hence the necessity of producing them by mechanical means. On the plant, jute exists in a series of layers concentric to the stem, superimposed one over the other, and bound by a gummy substance. The latter is got rid of by steeping; but still the tearing action of heckles or cards is necessary to reduce the fibre to working condition. The carding engines are of a strong make, but their mode of operation is similar to that of the machines used in dealing with flax, cotton, &c. The same remark applies to the spinning machines. A considerable quantity of loose fibre falls out in the process of working, and the machinery is adapted for the escape of these. The card and other droppings are carefully collected, and subjected to the operation of a number of iron arms mounted on an axis, and caused to revolve rapidly inside a casing. In this way the dust and rubbish are removed, and the residual fibre is then mixed with other and better material, and sent through the carding and spinning machines. This is only one example of many that might be given in illustration of the rigid economy that prevails in all departments of this vast establishment.

As the visitor makes a circuit of the works he is able to follow the jute from the stores through all the successive operations till it is converted into a marketable commodity, packed by hydraulic power, and put on the railway for transportation. The weaving-shed presents a busy scene, and the noise of its 820 power-looms is something to be remembered. These looms are engaged upon plain or twilled sacking, and the other fabrics usually made of jute. In a smaller room, seventy hand-loom weavers are at work upon carpetings. Messrs. Cox have devoted much attention to the carpet department, and have produced an article which, having regard to appearance and price, is a triumph of manufacture. Some of the jute carpeting turned out is sold so low as 3½d. per yard. The coloured yarns required for these and other fabrics are dyed in a special department. The jute fibre takes dyes readily, and the most brilliant hues may be imparted to it; but unfortunately it does not long retain them in full brightness. Still, the fact that a richly-coloured carpeting can be had at the price mentioned is an important consideration, and removes one reason why the abodes of even the poorest of the working class should be so bare and unattractive, as in too many instances they are.

One thing that will not fail to strike the visitor is the extent to which steam-power is made available. Wherever a steam-engine or connection with one can be useful, there it is. The engines vary from 1 to 120 horse-power each, and the aggregate indicated horse-power is 2,560. Steam for these and other purposes is generated in thirty-two boilers, each thirty-five feet in length and seven feet in diameter. The boilers are ranged in two rows, and, with the noble chimney-stack that carries off their smoke, constitute an imposing feature of the works. The chimney is of ornamental design, and



Camperdown Linen Works, Dundee.

from a base thirty-five feet in diameter rises to a height of 300 feet. The building of the chimney alone cost £3,000. Upwards of 23,400 tons of coal are consumed annually in the furnaces. There are employed in the establishment no fewer than 4,500 workpeople, a large proportion of whom are women. The firm also keep in regular employment some hundreds of sack-sewers, who work at their own homes. As might be expected, the produce of such an extensive organisation of labour is enormous. The annual turn-out is no less than 21,000,000 yards, or nearly 12,000 miles, of different fabrics, all of which are calendered, finished, and packed on the premises. For assisting in the movement of raw material and manufactured goods, thirty horses are constantly employed, and for providing food for these animals there is a farm adjoining the works.

One important accessory of this truly magnificent establishment remains to be mentioned. There is within the gates a commodious school for the education of the "half-timers" and other children of the workpeople. The school, which is under the inspection of the Scottish Education Department, has a head-master and four assistant-masters, and the average attendance is 350 boys and girls, besides whom 120 children, attached to the works, attend the Roman Catholic schools in the village. It is an interesting sight to see the workpeople leave for meals or at the close of the day, and no one who witnesses it can fail to be struck by the healthy, cheerful, and tidy appearance of all, especially the young women, who look quite smart in their snow-white pinafores.

Dundee has profited largely by the enterprise of its merchants and manufacturers in introducing and developing the jute manufacture. In devoting attention to jute, the manufacturers did not relinquish their hold on the older fibre of flax, which had been their staple for so many years, but they took jute on hand as an auxiliary branch of business, little dreaming, perhaps, that it would one day become the most important. The average quantity of flax imported by them during the last half century has been about 30,000 tons per year, the later returns showing no decided extension of the trade. Jute, on the other hand, advanced steadily until, so far as quantity is concerned, it overtook and passed flax upwards of twenty years ago. In 1848 only 8,905 tons of jute were taken by the Dundee mills. By 1858 an advance had been made to over 30,000 tons, and in 1865 not less than 116,523 tons were taken. The two fibres together imply a large carrying trade, and to meet the requirements of this, ample dock and other accommodation has been provided. Nay, more: the manufacturers have in several cases embarked some of their capital in this external branch of their business, and bring their jute from Calcutta in vessels owned by themselves. The number of flax-laden vessels entering the port in each year is between one and two hundred, and they belong chiefly to the north of Europe. In the jute trade larger vessels are employed, and the fleet has in some recent years included no fewer than twelve fine steamers. As there is a considerable trade at both London and Liverpool in jute, some manufacturers purchase in those markets, so that the whole quantity used in the town is not water-borne, as much as 20,000 tons being some years delivered by rail.

The jute trade has suffered during the last few years from causes which some people fear will lead to its serious curtailment, if not to its entire extinction, before many years are past. Mr. Walker, Assistant-Inspector of Factories, in a report dated April 30, 1875, comments on the marked decline which had taken place in the jute trade of Dundee during the preceding two years, and says:—"This untoward condition of the jute trade is all the more striking in so far as it is the only serious reverse it has sustained for many years. It is attributed, in some measure, to the great increase of jute factories in this country and on the Continent, as well as in America and India. The working hours on the Continent and in America are much longer than ours; and in the Indian factories the mode of working differs materially from that adopted in this country, owing, it may happen, partly to the abundance of cheap labour, and partly to the effects of climate. In Bengal, where alone the jute-plant is cultivated, jute-spinning and weaving factories have of late been established with great rapidity. A few years ago only four such establishments existed there, whereas now there are fourteen either in actual operation or in process of erection, aggregating about 60,000 spindles and 4,000 looms, and capable of producing annually at least 30,000 tons of manufactured goods, almost entirely of the coarsest description. This enormous production must, for a time at least, operate prejudicially to the manufacture of like fabrics in this country. And it is to be dreaded that, whilst in this country, as compared with India, labour and raw material are more expensive, the trade, so far as regards its coarsest branches, may be diverted from this district.

I may mention that in India two sets of hands are employed, the one working eight, the other four hours a day, and so alternating. The machinery is thus run twelve hours a day, or seventy-two hours a week—just sixteen hours a week longer than in this country. The Calcutta jute manufacturers have a complete monopoly of their own home markets, as well as of those of the Eastern Archipelago, including Singapore, Penang, &c., with which and Calcutta there is frequent and regular communication. Looking, therefore, at the advantages which they possess in the ample command of cheap labour, now becoming trained and skilful, and in being able to procure the raw material at least thirty per cent. cheaper than we, it is feared by persons conversant with the trade—not alarmists, but intelligent mercantile men—that the time is not remote when our Indian manufacturers will become formidable rivals to their brethren in this country." Since the foregoing was written the state of matters at Dundee has not improved, and the causes operating against the jute trade, as described above, have undergone further development.

There are two sides to the picture, however, and the following extract from a statement prepared for the Government by Mr. J. E. O'Connor on the trade of British India for 1877-8, shows that, notwithstanding the advantages attending the manufacture of jute in India, it has not, so far, been profitably carried on in the great factories established there during the last few years. Mr. O'Connor says:—"The figures of the trade in raw jute for the last five years are these:—

	Cwts.	Rs.
1873-74	6,127,279	3,43,60,147
1874-75	5,493,957	3,24,68,823
1875-76	5,206,570	2,80,53,396
1876-77	4,533,255	2,63,66,466
1877-78	5,540,276	3,51,81,137

There was a material increase in the average value which was declared at Rs. 6·4 per cwt. as compared with Rs. 5·8 per cwt. in the previous year. As stated in my review for 1876—77, this increase is to be attributed to a great extent to the demand for manufacture in Calcutta, stimulated as it was to an abnormal degree both by the enormous export of grain to the famine districts, as well as by the active export trade for other countries. Although, however, there is an increasing demand for bags and cloth of Calcutta manufacture, it can hardly be said that the jute-mills here are flourishing, and it must be admitted that in a great many cases their financial ill-success is due to the cause which has injured the cotton-mills of Bombay—viz., incompetence and expensive management. Where the mills are the property of individuals I understand that they give returns which are considered satisfactory enough; where they are managed by directors of a Joint Stock Company they seem in many cases to pay the dividends, when any are paid, from the capital. That such a state of things should exist is not creditable to the industrial community of Calcutta; it would be difficult to name any enterprise which has such numerous and important elements in its favour as that of jute manufacture on the banks of the Hooghly. Labour, fuel, and the raw material are cheap, abundant, and procurable on the spot, and the mills are in the midst of the market where their productions are required either for local consumption or for shipment. If, then, under these conditions the mills are not remunerative to shareholders, the failure must be set down to something else besides the vicissitudes and misfortunes of trade. The values of the export of jute manufactures for the last five years were as follows:—

	Rs.
1873-74	20,16,686
1874-75	23,86,398
1875-76	48,91,813
1876-77	71,94,776
1877-78	77,11,270

The manufactures consist mostly of bags—corn sacks, rice bags, wool packs. Australia is the largest customer of the mills, and following next are the United States, China, and the Straits, Egypt, and the various Asiatic markets. During the last three years considerable quantities of bags have been sent even to England. The rise in the price of jute, of course, induced an increase in the price of bags, and therefore, although the total value of the trade exhibits the large increase apparent from the figures given above, the actual exports of bags fell off to some extent."

HEALTH AND DISEASE IN INDUSTRIAL OCCUPATIONS.—X.

IRON, STEEL, AND STONE WORKERS, AND THEIR DISEASES.

By Andrea Rabagliati, M.A., M.D., Hon. Surgeon to the Bradford Infirmary.

IRON dust is not so dangerous to the workman as some other kinds of dust; neither is it in general the sole hurtful agent in those cases where it exerts undoubted injurious effects, as it is commonly mixed with other sorts of dust, particularly that from the grindstones. Like other kinds of dust, iron may be in coarser or finer particles. Of these the former is much the less dangerous, since from their great weight it is almost impossible that the particles can be carried by the air and so find their way into the lungs of the workers. The finer sorts, however, especially those given off in the grinding processes, and particularly when grinding is carried on without the use of water to moisten the stone and clog the dust, exert a very hurtful influence on the operatives. Besides these dangers from dust—dangers common, as we have seen, to so many industrial occupations—iron and steel workers, and chiefly those operatives who make the various sorts of steel ware, suffer from affections induced by the rapid and extensive changes of temperature to which their occupation exposes them. Blacksmiths, blade-smiths, locksmiths, and file-makers, are subjected to alternations of heat and cold which are very trying to the operatives, and which leave their mark on their constitutions, particularly in the liability these people show to be affected by inflammatory disorders. This liability it will not be difficult to understand if it is remembered that hard work in a heated atmosphere, by causing a relaxation of all parts of the body, and specially by the free perspiration and excited action of the skin induced, renders the workmen liable to the checking of the perspiration when they are suddenly exposed to the cold, thus driving the blood into the internal organs, which then become either congested or inflamed. The consequence is, that while cutlers, for instance, who are not exposed to these sudden changes of temperature show a percentage of only 3·2 of all illnesses from inflammation of the lungs, and 6·3 from rheumatism, blacksmiths, on the other hand, and farriers, show a percentage of about 6·5 who are affected by inflammation of the lungs, and of nearly 10 who suffer from rheumatism. As the dust, or rather scales, given off under the hammer in the workshops of farriers and blacksmiths are so large as to fall to the ground by their own weight, they do not make their way into the lungs like the finer kinds of dust; and we do not therefore find a very large proportion of the workmen suffering from the consumption and chronic bronchitis which we have now learned to look upon as the effects of dust in general. From tables compiled by Dr. Hirt in his elaborate inquiry into the frequency of disease in various occupations, it appears that while nearly 11 per cent. of all the cases of illness among blacksmiths is due to consumption, and nearly 10 per cent. to chronic bronchitis, no less than 62·2 per cent. is due to consumption among hand file-makers, and 17·4 to chronic bronchitis—an enormous difference, which is due to the large amount of dust given off in file-making, as compared with the comparatively small amount produced in the former occupations. This difference will be intelligible, when it is remembered that the work of the file-maker consists of graving fine parallel excavations, leaving ridges between, by means of hammer and chisel, on pieces of iron already prepared for the purpose by the previous work of the smith. A large quantity of dust is thus generated, whose effects are, in general, much aggravated by the practice obtaining in the trade of rubbing sand on the anvil in order to prevent the iron from slipping, the consequence being that at each stroke of the hammer a large cloud of dust composed of fine particles of iron and sand is set in motion. Another adverse influence in the file-making trade is the great bodily exertion involved in the production of the larger files, when the workman has to use a large hammer weighing sometimes as much as six pounds for hours together, while an ordinary man who might be quite as strong as most file-makers, but unused to this occupation, would be fatigued after a quarter of an hour's work. In addition to this, the constrained position of the file-makers, leaning over the anvil, and with their eyes fixed on the parallel lines of the files, is said to exercise an injurious influence on their health.

Other iron-workers are wire and wire-nail makers, with the makers of needles and steel pens. In the manufacture of wire and wire-nails there is little or no dust generated; consequently this occupation has little interest from our point of view. To the manufacture of needles, of steel pens, and of steel wares in general, we must devote rather more

attention on account of the dust generated in their production; although it is only during the grinding process that the operatives are much troubled with this nuisance. The manufacturers of these goods are exposed, like blacksmiths, to sudden changes of temperature, and hence we find them suffering from affections due to sudden exposure to cold, such as congestion of the brain and lungs, &c. In addition to this, the excessive use of special muscles, or groups of muscles, is apt to induce deformities; hence the workmen engaged in these occupations suffer from time to time from overgrowth of certain parts with deficiency in others, and occasionally from paralysis, spasm, &c. Needles, steel pens, and other articles of steel ware, are ground upon stones made, as a rule, of sandstone. These generally revolve with great rapidity (2,000 to 3,000 times a minute), and in the grinding process fine particles are given off both from the steel which is being ground and from the grindstone. This process may be conducted with or without some moist lubricant, the dry process creating naturally a very much larger quantity of dust and being much more dangerous to health than the other. This dust varies in size and fineness and fills the air of the workshop, so that contained articles are soon coated over with a thick layer of it. In the sunlight the particles can be seen to glance and shine, and they cause a metallic taste when breathed into the mouth. Under the microscope, steel particles of different sizes can be made out with which particles of sand, round or sharp-edged, are mixed up. All kinds of steel ware—scissors, knives, forks, needles, and steel pens—are subjected to this process, and therefore this dust is generated in their manufacture. The effects in general are so unhealthy, that when ventilation is either absent or deficient, it is stated that such a phenomenon as a perfectly healthy grinder who has been at the work for any length of time, simply does not exist. The dust, which at first irritates the lining membrane of the air-tubes, gradually attacks the lung-tissue itself and sets up a condition like that found in consumption, and which is known as "grinders' asthma." This disease is accompanied by the irritative symptoms so often referred to, and on examination after death, iron-dust—in various forms of oxidation and combination—has even been found in the lungs. In Sheffield, according to the investigations of Dr. Knight, this and kindred affections were so common that no fewer than seventy out of every hundred grinders were affected with some disease of the chest. Among other operatives in general the proportion, according to the same authority, was only 22 per cent. It ought to be said, however, that this enormous proportion of illness does not seem to be a necessary accompaniment of the occupation, because, according to Dr. Hirt, nothing approaching it obtains in the workshops in some parts of Germany. Dr. Hirt has made a careful investigation into the condition of the German needle-grinders in the towns of Iserlohn and Aachen, which produce between them twenty-five millions of needles a week, and, strange to say, the result of his inquiry is that needle-grinders do not furnish a larger contingent of sufferers from chest affections than other workpeople. "People," he says, "who had stood over the grindstone in the same work-room day after day for four years were in perfect health, and had not during the whole duration of their work suffered once either from cough or from pain in the chest." These remarkable results he ascribes in great part to the great attention which has been paid in these places to the ventilation of the work-rooms. On comparing the duration of life among needle-grinders in the above-named German towns with that obtaining in Sheffield, equally astounding differences appear. Thus, in Iserlohn, from 1865 to 1869 inclusive, the average age of needle-grinders who died during that period was fifty years. In Derbyshire, on the other hand, the average age at death was only thirty years and eight months. Further, of 102 scissor-grinders, whose deaths were registered in Sheffield, sixty-nine died under forty years of age, while the oldest was hardly sixty-five years of age. In Iserlohn, on the contrary, no less than half the workpeople attained the age of fifty-five years, while one of them died at eighty-five. According to Dr. Fox Favell and Dr. Holland, fork-grinders, for the most part, die at about thirty-five years of age, while razor-grinders do not live beyond forty or fifty years. In some German towns, things are as bad as in England, and much worse therefore than in the German towns already named, it being stated that in some parts of that country the average duration of life among grinders is only thirty-one years. There can, therefore, be no doubt that hundreds of grinders (if not thousands) die in the bloom of their youth, while from the comparison just made with the workshops of Iserlohn and Aachen it is evident that rigid attention to precautionary measures might effect a great increase in the average duration of life.

Stone-cutters, and stone-workers of all kinds—hewers, quarrymen, the makers of mill-stones, agate-

workers, and diamond polishers, suffer much in health from conditions arising from their occupation. In the working of agate, four conditions are mentioned by writers as tending to make the occupation unhealthy: First, the position assumed by the workmen, who are obliged to work leaning upon a piece of hollowed wood, the so-called grinding stool, whereby the belly and chest of the operative are subjected to considerable pressure, and the free movement of the chest walls prevented and interfered with. Secondly, the great amount of physical force required to press the thing which is to be ground against a large grinding-wheel driven by water or steam-power. The force required is so considerable as to cause the workman to be bathed in perspiration. Thirdly, the development of dust, which, however, as the grinding is effected moist, is not very considerable. Fourthly, the liability of the workpeople to get wet from the spattering caused by the wheel, and which the very thin clothing they wear—in order to lessen the perspiration caused by the laboriousness of their occupation—renders all the more dangerous. In consequence of these influences, agate-grinders have, as a rule, a leaden, bloodless appearance, and suffer very much from chest affections, as much owing to the position assumed by the operatives as by the dust arising from the work. From inquiry it would appear that the average duration of life among this class of people is from forty-five to forty-eight years. Similarly, we find workers in the uncrystallised flint which is used for the manufacture of some kinds of pottery suffering very much in health, and it is stated that after the production of this material was encouraged in the Department of Cher-et-Loire in France, consumption became epidemic, and the average duration of life sank to nineteen years. Marble-workers suffer in a manner quite analogous, and so do the workers in granite, basalt, gneiss, &c., who furnish a large proportion of sick from among their numbers. From inquiries into the sickness among stone-hewers, it appears that 61 or 62 per cent. of all illness among these workpeople is due to affections of the chest, and that 36 of this percentage is due to consumption. Of the remaining 38 per cent. who suffered from other diseases than those of the chest, 13 suffered from rheumatism, and 5 from affections of the stomach. The duration of life is very low among stone-hewers, being variously stated at from thirty-three to forty years. The operation of quarrying has points of analogy both with stone-hewing on the one hand and with mining on the other, though there is less dust produced than in the former occupation, and, of course, quarrymen do not often have to work in the dark like miners. They suffer from liability to take cold, chiefly from being compelled to work with their feet in wet, cold places. They are consequently liable to inflammatory attacks of all kinds, but chiefly to inflammation of the lungs and bowels, and also to rheumatism. In addition to these evils, various injuries from sprain, rupture, &c., are often sustained by men who have constantly to bring to bear on their work excessive muscular exertion. Sprains of joints are very prolonged and often very intractable injuries, which occasionally incapacitate permanently men who are compelled to do heavy work. The injury almost always occurs to the fibrous ligaments which pass between the contiguous ends of the bones of such a joint as the knee, for instance. Such ligaments get stretched, or it may even be ruptured. This is immediately followed by swelling both in and around the joint, so that after a day has elapsed it is often very difficult to say what the injury has been. If very severe, the sprain commonly leads to inflammation of the other parts composing the joint, and after the swelling has subsided, results in general thickening of the structures, which impedes free movement. In addition to this, there can be no doubt that occasionally fibrous bands form within the joint and about it, which bind the bones to one another and prevent movement. These bands do not disappear with the lapse of time. On the contrary, they prevent movement the more effectually the longer their presence is unrecognised; and hence the rest which the owner of such a joint is generally recommended to take is, after a certain time, positively injurious to him. The proper treatment of such a joint is first, of course, to rest it till the inflammatory symptoms have subsided, but after a fortnight or three weeks the joint should be freely moved in the direction proper to it. When this is done, the joint often cracks or snaps, after which it is free and can be moved without pain. The cracking or snapping of the joint, followed as it is generally by complete freedom of movement, is often looked upon as proof that there was a dislocation which it is supposed was reduced at the moment of the snapping. This is, however, not at all the case, as may be proved by the facility many persons have of snapping the joints of the fingers, for instance, while some can produce similar sounds from other joints at will. There is even yet some obscurity as to the cause of this phenomenon, but it, no doubt, is frequently produced by the rupture of

the adventitious bands which are formed in the course of inflammation after sprain.

As to precautionary measures, the statements made on the authority of Dr. Hirt about the needle-grinders of Iserlohn and Aachen show what can be effected by good ventilation. The use of respirators would also very much impede the entrance into the lungs of the dust which is the main hurtful agent in producing the diseases of industrial life. In the case of iron and steel dust, an ingenious use of the magnet has been suggested. The proposal, which has been followed by the happiest results when it has been carried out, is to make the respirators of fine magnetic iron, which not only prevents the ingress of dust by its mechanical arrangement in the respirator, but also by its attractive power for iron and steel particles makes them adhere to itself. The adoption of this happy suggestion at once proves to the eye the presence of the iron particles which can be seen collected on the magnets, and has been the means of saving life and avoiding disease to an extent which might have been much greater but for the unfortunate prejudice presented by ignorant workpeople to a measure proposed solely in their interests. The opposition offered to the introduction of this and other means of ameliorating their condition, has been used as a text for the desirability of further instructing the mass of our workpeople, and I cannot help thinking that better education in the practical construction of their own bodies might perhaps be the best means of preventing those injuries to which quarrymen and others who do heavy work are liable. A knowledge of the structure and composition of a joint would, at least, do no harm, and so long as machinery is not used for the heavy work of stone-getting, it might at least teach the workman both what are the proper directions for applying weights, and how much weight it is safe to attempt to move or lift.

COTTON.—XXVI.

THE TRADE IN RAW COTTON AT LIVERPOOL.

BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

It was inevitable that as Manchester and the other towns in the North-west of England, which had applied themselves to the cotton manufacture, extended their borders, the port at which the raw material of the trade was received, and whence the goods manufactured were sent for shipment to all the markets of the world, should experience a proportionate growth. We accordingly find that the progress of Liverpool has borne a close relation to the development of the cotton manufacture. In the year 1700, the population of the town was only 5,740, a century later it was 75,000. From that point it rose in thirty years to 205,570 ; and now it is close upon 540,000. Over 5,000 ships, of an aggregate of nearly four million tons, enter the port every year; and the value of the goods exported in them has, during the last ten or twelve years, ranged in value from seventy to ninety million sterling, a goodly proportion of which was the produce of the Lancashire cotton-mills. Cotton-laden ships arrive almost daily; and among the crowded traffic in the vicinity of the docks, drays laden with mighty piles of cotton bales are a conspicuous feature. For the storage of cotton, there are warehouses in various parts, and a large proportion of the cotton rests in these for a longer or shorter time, waiting purchasers.

An account of the trade in raw cotton at Liverpool was submitted by the Cotton Brokers' Association of that town to the International Cotton Convention, and from that we glean some interesting particulars of the business. As soon as a cotton-laden vessel is docked, and placed in a berth, her cargo is discharged by a stevedore, who is appointed by the captain. The bales are broken out and hoisted on deck by means of "dogs," which consist of ropes, with hooks at one end. The hooks are fastened in the bales, and the ropes are attached to a winch, usually worked by steam, and, in this manner, the bales are dragged out of the ship's hold. After being hoisted on deck, they are rolled down a gangway to the quay, where they are weighed, for the purpose of calculating freight, after which they are delivered by the master porter to the various consignees. Any bales much torn or damaged in being discharged are mended at the expense of the vessel, the captain generally making a contract to mend the cargo for a lump sum, and the result is that only thin gauze canvas is placed upon the bales, loosely

and hastily sewn on, and which is barely sufficient to protect the cotton until it reaches the warehouse. The cotton which is torn from the bales, and left in the ship's hold, is collected, and distributed, *pro rata*, among the consignees of the cargo.

STRAND STREET, LIVERPOOL.

Cotton intended for sale in the market is generally sampled, as it enters the warehouse, by the broker. If necessary, one or more bands, or iron hoops, as the case may be, are removed, the wrapper is cut, and the top layer of cotton turned back. A sample is then drawn of about six ounces, which is reduced, by having the loose cotton taken off, to about four ounces. By these samples the cotton is sold; but, before leaving the warehouse, the bales are again sampled by the buying broker, who compares his samples with those by which he bought. When cotton is sold "to arrive," the buyer does not sample until the whole parcel is in the warehouse, and declared ready for delivery; this necessitates the cotton being so piled as to enable the buyer to draw a good solid sample from each bale. Before leaving the warehouse the bales have to be properly mended. Any wet or damaged cotton is picked off, torn canvas is replaced, and sample holes are stitched up. This mending is usually done at the time the cotton is being brought to the scale and delivered to the buyer, and is a cause of much delay and consequent expense.

After the bales are mended, they are weighed in cwts., qrs., and lbs., from which weights the invoice is made out. From these gross weights the following allowances are deducted in the invoice: draft 2 lbs. per bale, tare 4 lbs. per 112 lbs., and the actual weight of the iron or other bands, so that the total allowances on a bale of 440 lbs. gross weight would amount to 6·27 per cent. The buyer has the right to claim at the time of delivery that the actual tare shall be ascertained in his presence, which shall then be the tare allowed in the invoice, and no subsequent claim is admitted. When the ordinary tare, or that guaranteed by the seller, without examination, is allowed in the invoice, and is afterwards proved insufficient, the buyer is entitled to recover the deficiency, provided it amounts to half a pound per bale on the parcel purchased. The buyer must make payment within ten days from the date of purchase, but is allowed a discount of $1\frac{1}{2}$ per cent. In the case of cotton sold "to arrive," or "for delivery," it is the custom to demand payment before delivery, subject to the same discount of $1\frac{1}{2}$ per cent.

Every lot of cotton is sold warranted to be as represented, both in quality and description. If, on re-sampling, the buyer finds the quality not equal to the samples by which he bought, he can claim to cancel the purchase. If, after taking delivery, he finds any of the bales to be falsely packed or unmerchantable, he can return the same to the sellers any time within three months and ten days from date of the purchase, and all claims for falsely-packed, damaged, or unmerchantable cotton are allowed at the value of the sound cotton at the date of return. After cotton has been sampled by the broker, he carefully classes and values it, sending his report to the principal. When placed upon the market for sale, the sample papers are ticketed with the mark, the number of bales, the ship's name, and port of shipment. These samples are then laid before such brokers as may be in want of that particular class of cotton,

...e sent to the buying broker's ...em with other lots offering,

...per ship or ships, or ...n port, the name of ...of the cotton, are ...buying broker ...nth of ship- ...han one ... ship- ...n in ...n like ...om the ...en made ...ned period, ...to the seller, ...name to the ...ing such appli- ...s the option of ...voicing the cotton ...which is decided by ...being less than ⅛d., ...ove the market value ...on the day upon which ...red. In cases where the ...nder the provisions of this ...ing declared, the weights per ...r Mobile and Texas 468 lbs., ...s ports 432 lbs. If the weight ...ore than 5 per cent. from the ..., the whole excess or deficiency ...ge shall be settled for at the market ...cotton contracted for on the day of the ...of the arbitration, but this ...o apply to contracts when the ...ame is given. In contracts to ...for "ship named," or "shipping ...pped," it is understood, unless ...wise expressed, that the ship or ...s named have already sailed from, or ... in the port named; and, should it ...terwards appear that the ship or ships have not at the date of such contract arrived out at the port, the buyer has, on becoming aware of the fact, the option of closing the contract at once, or of requiring the completion of his contract by the declaration of cotton by a ship which had sailed from or arrived at the port named at the time the contract was made. Should the cotton tendered on an "arrival" or "delivery" contract not be in accordance with the terms of the contract, the buyer has the option of taking such portion, with the allowances awarded by the arbitrators, or of returning it to the seller at the market price of the day, together with a penalty of ⅛d. or ¼d. per lb. The principle which underlies all these contracts is that they shall not be cancelled on any ground, except in respect of cotton lost at sea, but that a defaulter shall be made to pay a penalty, and take the cotton back at the market price.

The Clearing House is a recent institution, and has proved a most convenient medium for settling all arrival transactions. The process is an extremely simple one, consisting of an arrangement by which the first seller and last buyer are brought together, and the differences on the intermediate contracts are collected in the Clearing House and distributed to the parties interested. A special committee of the Cotton Brokers' Association has charge of the Clearing House, and sits daily to settle questions which may arise on future contracts other than those relating to the quality of cotton. The committee is elected by and from the Association, and consists of twelve members, four of whom retire annually by rotation, and are ineligible for re-election for two years. This committee is the final court of appeal to whom all disputes in the cotton trade are referred for settlement. When required to adjudicate upon quality, the samples are sent to the Association rooms, and the samples are submitted without the committee knowing who are the principals in the transaction. Members of the committee are not allowed to undertake ordinary arbitrations. The fee for an appeal is £3 upon a

WAPPING DOCK AND WAREHOUSES, LIVERPOOL.

contract not exceeding 100 bales, £5 when over 100 bales and not exceeding 200 bales, and £1 additional for each 100 bales or portion of 100

bales over 200 bales. It is a rule that all disputes connected with, and arising out of, contracts made in the Liverpool Cotton Market, shall be settled by arbitration. The disputing parties, buyer and seller, each appoint an arbitrator, who must be a member of the Association, and who, should they fail to agree, calls in an umpire, also a member of the Association. From this award the buyer or seller has a right of appeal to the committee of the Cotton Brokers' Association. Such appeal must be lodged with the secretary of the Association, before noon of the day following that on which the arbitrators gave their award, and the award of the committee is final and binding.

A special committee of the Association meets daily at noon, when the official quotations are considered and fixed, and an estimate of the amount of the day's business is given out. No estimate is made of sales "to arrive" and "for future delivery." On each Thursday afternoon another committee meets, which revises the quotations prior to appearance in the printed circular issued on Friday; also, on each Thursday afternoon, returns are sent in from all brokers to the secretary's office, of the cotton they have sold during the week, likewise of the cotton purchased on speculation and for export. These statistics of sales, &c., are declared at the general meeting of the Association, which is held every Friday at ten a.m., and, from these returns, the figures in the weekly circular are compiled.

Standard samples of "good middling, middling, low middling, and good ordinary," are made up in duplicate once a year by the Cotton Brokers' Association, and these samples are invariably referred to by the committee when investigating an appeal. Of these, one set is put in a box covered with glass, and this set is never opened or referred to except in the presence of the President.

Some additional details of the customs of the trade are given in the following extract from an Oldham newspaper describing the proceedings of buyers from that town:—"When the Oldham representative arrives at the office of his cotton broker in Liverpool, he is shown samples of the various lots of yarn in the market. The price is named, but the buyer is emphatic that his company cannot afford to pay the price. He often expresses a wish to go round amongst the cotton-holders, and in this expedition is, of course, accompanied by the broker himself. The two soon enter offices, where there are to be found samples of cotton made into bundles about 2 ft. long and 8 in. thick. The broker may inquire whether there is any low-middling at 5½d. to 6d., or Surats at 4½d. to 6d. A sample is placed upon the counter, and opened. There may be ten to twenty 'lumps' of cotton in the sample. One piece after another is pulled out to test the staple, and the parcel is then knocked with the fingers in order to see whether there is much sand. All the pulled cotton is thrown into a recess, these 'pickings' forming a perquisite of the broker. If the cotton be found suitable, the buyer will offer a lower price—because one seldom closes with a price all at once—for it, perhaps ⅛d. or ¼d. per lb. below the figures asked. The buyer then requests the holder to send samples to the company's broker's office. Other places—perhaps twenty or thirty—are visited, and when the broker and manager return to the establishment of the former, they find that the number of samples as ordered have arrived. The samples are again examined. On the back of the paper is the number of bales, and a list of the prices. For the most suitable cotton a second bid may be made, which may or may not be accepted. If accepted, and the number wanted be purchased, the broker keeps the sample to be returned to the company after undergoing a process which, in Oldham, we are told, is conventionally termed 'dressing.' The broker then sends a person to the warehouse where the bales are stored, and this party 'draws' a sample of cotton out of each end of every bale. This proceeding is termed 're-draws.' After examining these 're-draws,' the party says whether the bales are equal to sample or otherwise. If everything is found right, the bales are marked, and ordered for delivery. The money for the cotton is in some cases sent to the broker to be paid by him; in others it is sent direct to the owner. The latter mode of settlement is considered to be the more preferable of the two, for in addition to whatever advantage may be derived from a question of safety, a direct settlement is soonest concluded, and least liable to miscarriage. The next step is for the broker to send a delivery note to his client's mill, stating the number and mark of bales, and the purchase price. The broker charges 10s. or ½ per cent. for every £100 worth of cotton delivered, together with a 'forwarding charge' of 6d. per bale."

WOOL AND WORSTED.—XXIII.

BRADFORD, ITS TRADE AND SPECIALTIES.—FIRST PAPER.

By William Gibson.

THE metropolis of the worsted manufactures may be proud of the industrial pre-eminence she has attained within the last half-century, and recall with pride that she had in her midst men enlightened enough to favour the introduction of mechanical appliances, at a time when the great mass of manufacturers and operatives looked upon machinery as a device of the Father of Evil to deprive them of bread. But it was not always so. When Mr. Buckle, in 1793, proposed to erect a cotton mill in the Brick Kiln Field, Manchester Road, opposite the site of the present Primitive Methodist Chapel, the aristocratic inhabitants of Tyrrel Street opposed it with such virulence that the scheme had to be abandoned. The petitioners alleged that the smoke from the chimney-stalk would suffocate them, and among the signatories were men who subsequently became pioneers in the worsted trade, among them Messrs. Rand, Aked, and J. Smith. Considering what occurred in Bradford within the first decade of the present century, it seems incredible that a member of the firm of Ramsbotham, Swaine, and Murgatroyd should have been obliged, as recently as 1798, to strip his coat and literally fight his way through an infuriated crowd before he was able to deposit the first cart-load of stone for building the factory in "The Holme," which became the earliest sample of those magnificent workshops for which the town and district are now so notable.

Like a great many other places, the Yorkshire town has an ancient connection with the woollen manufactures. In the Hundred Rolls of 1284 mention is made of a cloth-weaver of Gomersal named Evans. Frizing Hall, probably named after the frieze cloth so common in those days, dates as far back as 1287; and we know that among the Earl of Lincoln's possessions, in 1316, was a fulling mill; while Leland declares that in the reign of Henry VIII., Bradford had a flourishing clothing trade. It is also beyond dispute that in the reigns of Edward III. and Elizabeth large contingents of immigrants from the Low Countries settled in the district—the local dialect of to-day, saturated as it is in Flemish phrases, being the incontestable proof—and improved the processes of manufacture. Unfortunately this promising trade was almost destroyed during the Parliamentary War, and was not revived until the beginning of the eighteenth century. From what quarter the revival came is uncertain; but shortly after the peace of Ryswick, which was concluded in 1697, we find Norwich manufacturers largely employing the inhabitants of Wharfdale and Airedale to spin their yarn; and among the woollen centres from which protests were sent to Parliament in 1752, praying the legislature to free wool-combers and cloth-makers from the losses sustained by farmers encumbering their fleeces with tar-marks and other obstructive material, Bradford took an honourable part. Two circumstances which occurred about this time materially assisted the rising little Yorkshire town—one, its proximity to Lancaster, to which port Irish wool now began to be exported; and the other, the signing of the commercial treaty with Portugal, which allowed her to ship her produce to that country from Liverpool and Hull, both easy of access. But, above all, the success which was speedily realised was due not so much to adventitious events from the outside, as to the frugal, industrious, keen-witted, enterprising character of the people themselves. Unlike the working classes in Norwich and other industrial centres, the "canny" Yorkshireman had simple tastes, few wants, an honourable ambition to produce the best possible work, and a dogged perseverance which enabled him very speedily to outbid other skilled labourers and attract to his native county an ever-increasing demand for work. Farmers, instead of following the questionable example of other agricultural districts into which manufactures had come, did not neglect their ploughs and scythes because tempting offers of higher profits were held out to them. Farming in those days was a leisurely occupation, and the dalesmen round Bradford simply filled up their spare time by combing, spinning, buying wool, and selling yarn. In every homestead the mother and daughter plied their spindle, or two-thread wheel, all the lads became proficient as sorters and combers, while the father on his stout cob scoured the Midland district in search of the cheapest and best wool, or, packing the evenly spun yarn before and behind him, travelled long distances to sell the produce of his industry in the dearest market. In time, of course, they had to choose between their farm and commerce, but

not until in every valley there were spinning, combing, and sorting schools, and the Yorkshire yarn, shalloons, and calimancoes had become notable in Europe, Asia, and America.

Bradford, from the middle of the seventeenth century, was the centre of the Yorkshire woollen industries, although she had strong competitors in Leeds, Halifax, and Wakefield. Prior to 1773 buyers from far and near began to congregate at the White Lion Hotel, Kirkgate, on the Thursday forenoon to carry off the cloth and yarn; and when the Piece Hall, which was erected in that year, was opened, as many as 3,000 pieces of cloth, besides a considerable quantity of warp and weft yarn, were disposed of in a few hours. Mr. Horsfall, the progenitor of the famous firm, was the first to introduce the weaving of shalloons, and Mr. James Garnett set up the first spinning machine in Paper Hall, High Street, about 1780. As has already been stated, the first mill was erected by Messrs. Ramsbotham, Swaine, and Murgatroyd in 1798, in which was worked a combing machine of the Cartwright type with Hawksley's improvements. Other mills speedily followed: Richard Fawcett's in 1801, Matthew Thompson's in 1802, and John Rand's—he who signed the anti-cotton factory petition ten years before—in 1803. From this point Bradford began to take the lead, and her advantages of situation—close to the great coal and iron fields, on the line of the Leeds and Liverpool canal, near navigable rivers—enabled her to advance rapidly.

The erection of Piece Hall in 1773 is really the starting-point of the Bradford trade; for although the surrounding district for half a century previously had been generally engaged in the preparatory processes to weaving, the work had been done mainly on commission for distant manufacturers and merchants. The original building was a plain, barn-like structure, 140 feet long by 36 broad. The interior was divided into two sections by a brick wall running down the centre. Against this wall on either side were built small square shops, twenty-five in the length of the building, on the ground-floor and upper storey, or 100 stalls in all. These were fitted with shelves to pack the goods, and a tiny counter served to show them to the buyers. The stalls on the ground-floor were occupied by the subscribers to the building fund, and those on the floor above were let out at an annual rental to those who lived at a distance, but found it advantageous to bring their goods to the busy market. The roof was surmounted by a plain cupola belfry, in which was slung a small bell. Precisely at ten o'clock on the Thursday forenoon the subscribers opened their stalls, buyers being summoned by the bell, which warned buyers and sellers at half-past eleven that the cloth market was over for the day. All retired to the various hostelries in the neighbourhood for the noon dinner. This meal was of the plainest and simplest description. Old Thoresby tells us the character of the *table-d'hôte* at Leeds in the early part of last century, and customs had not much changed when the Piece Hall at Bradford was opened. According to Thoresby, the usual market dinner consisted of a trencher of beef, boiled or roasted, a noggin of oatmeal porridge instead of vegetables, washed down by a pot of home-brewed ale. The cost of this dinner was twopence. Potatoes and vegetables were things practically unknown in the West Riding, and Mr. James informs us that in his early days—the beginning of the present century—most of the old people despised the new-fangled vegetables, and clung with tenacity to their oatmeal porridge. This primitive meal concluded, buyers and sellers were summoned back to Piece Hall exactly at two p.m., when the yarn market opened, and at half-past three the stalls were closed and locked until the following Thursday. The original building cost £1,555. It soon became too small, however, and New Piece Hall, containing 250 stalls of a more commodious character, was built. In addition to the weekly market, the annual custom of meeting in inns on Monday gradually increased, until, when the Exchange was built, it had come to be usual to sell yarns on the Monday, and pieces on Thursday. Gradually merchants from a distance found it necessary to have branch establishments in Bradford, and now houses in America, France, Germany, and the chief London firms have resident representatives. The Piece Halls have given place to the Exchange, but now-a-days the bulk of the buying and selling goes on quietly and unostentatiously in the vast warehouses that have been built in every part of the town.

With the erection of mills at the close of the last century, Bradford began to push herself out on every side; the hamlets of Wilsden, Horton, and Manningham were incorporated one after the other, and to wool-sorting, combing, and spinning, weaving, dyeing, and finishing were added. Rapidly as workmen were attracted to the busy centre, the demand for labour increased till every cottage, farmstead, and village in the surrounding districts became

workshops, and wool was sent out to be spun as far north as Darlington, as far west as Cheshire, and into Derbyshire on the south. But the occupants of the shops in Piece Hall continued to be wool merchants, staplers, and weavers. They had to travel into Lincoln, Leicester, Norfolk, Suffolk, and even Essex, for their raw material, which they transported to Bradford on strings of pack-horses, and then they were obliged to trudge on into all the dales of the West Riding to distribute the "top" — *i.e.*, combed wool—to the spinners in scattered nooks. Generally these master-men had agents in the villages and hamlets, who took top for the surrounding district and collected the yarn when it was spun. These agents were farmers, small shopkeepers, and such-like. The pack-horses that came into Bradford laden with wool, left it with a load of top, and returned home bearing yarn and cloth. Now the labour is subdivided into many sections. One merchant is exclusively engaged buying and selling the raw material, one factory sorts and combs, another spins, a third winds, a fourth weaves, a fifth dyes and finishes the textures, and the merchant stores and sells the marketable product. Some conception of the small margin of profit available to the master in return for his long journeys, persevering labour, and outlay of capital may be guessed at when we glance at the cost of producing a piece of stuff about the time the Piece Hall was opened. At that time about 9½ lbs. of wool were consumed in weaving a piece of shalloon. The raw material then would cost 12s.; the combing cost 1s. 11½d.; spinning, 6½ lbs. of warp yarn to 18 hanks, 6s. 1½d.; and 3 lbs. weft yarn to 24 hanks, 5s. 10d. Warping and winding the yarn would cost at least 8d., and the weaving 6s.—in all, £1 12s. 7d. The piece, when brought into the market, would fetch £1 15s., leaving a margin of only 2s. 5d. A piece valued at 30s. cost in wages 16s. 3d., and the wool, in 1774, 13s.—leaving a clear profit of only 9d. Yet these frugal and thrifty pioneers of the great worsted manufactures of Bradford not only managed to live, but saved money and gradually extended their operations till they realised immense fortunes.

A few figures will more eloquently set forth the rapid growth of the Bradford trade than any amount of argument and illustration. Let us first of all take the population of the borough. In 1800 Bradford parish contained 13,264; in 1811 it had risen to 16,012; in 1821 it stood at 26,319; in 1831 it was no less than 43,527, and in 1841 it bounded to 66,508. At the census of 1851 it was 103,778, or in half a century the increase was sevenfold. In 1861 the town had 106,218 inhabitants, and at the 1881 census 180,459, or nearly fourteen times as many people as at the beginning of the century. Now let us take the number of persons directly employed from the beginning of the century. In 1800 there were 1,290 persons engaged in the worsted manufacture; in 1811, 1,595 families; and if we take the average at 3, that will yield 4,785; in 1821, at the same rate 7,356; and in 1831, 11,601. Turning now to the horse-power of the engines, when Ramsbotham's mill was erected, in 1798, he laid down an engine of 15 horse-power. In 1819 the force is represented by 492 horse-power; in 1830, 1,047; and in 1840 over 2,000. But the surest test of the growth of the manufactures in the town is the amount of drawback allowed by the Excise on the quantity of soap used in the scouring of the wool. In the whole of the West Riding in 1803, then, the drawback allowed was about £1,500. In 1810 it was £4,993 0s. 3d., and of this amount the Bradford manufacturers claimed £1,260 10s. 9d. At this time the duty on hard soap was 2½d. and on soft 1¾d. per lb., so that the drawback for the West Riding shows that 9,600,000 lbs. of wool were manipulated, on the declaration of manufacturers, and in Bradford alone no less than 2,400,000. In 1815, £6,034 13s. 2d. was allowed the district, and of that Bradford manufacturers claimed £1,484 15s. 1d.; in 1820, £10,897 9s. 1d. was returned, and Bradford got £3,329 8s. 6d.; in 1825 the district obtained £17,050 3s. 5d., and Bradford £5,033 12s. 8d.; and in 1830 the larger area figures for £20,149 7s. 1d., Bradford alone for £6,948 6s. 7d. Within twenty years, therefore, the quantity of wool had risen from 2,000,000 lbs. manufactured in 1810 to something like 13,000,000 lbs. treated in 1830. The exports tell the same story. In 1810 there were exported from the district about 350,000 pieces; in 1815, 593,972; in 1820, 829,901; in 1825, 1,138,808; in 1830, 1,252,512; and in 1835, 1,673,000.

Bradford early adopted mechanical aids as they were introduced, and adapted itself with comparative ease to changing circumstances, but it must not be supposed that hand-labour was abandoned without a struggle. The power-loom was introduced into the town in 1825, and in the following year an attempt to extend its use occasioned a serious riot. The Messrs. Horsfall were pitched upon as the prime offenders against manual skill. On the 1st of May some 250 riotous

persons gathered in front of the mill in North Wing, broke a number of windows with stones, and retired to the moor. There they were joined by as many more dissatisfied operatives, and returned to the mill between eight and nine; but by this time the municipal authorities were prepared, the Riot Act was read, and the turbulent crowd eventually dispersed. On the following Wednesday a second gathering took place on Fairweather Green, and a third onslaught was made on Horsfall's factory between four and five in the afternoon. Colonel Tempest, the Superintendent of Police, with a body of police and the mayor, arrived when three windows, stanchions, and frames had been driven in, and a serious attempt was being made to carry the place by assault. The Riot Act was once more read, but some one in the crowd had the hardihood to fire a pistol. A number of workmen who were inside for the protection of the machinery thereupon lost patience and fired upon the crowd, killing two youths and wounding a number of other persons more or less seriously. The authorities eventually gained the upper hand, and after arresting several of the ringleaders, quiet was restored to the town. This was, however, the last outburst of popular fury against what Mr. James calls "never-tired, all-powerful drudges."

Close upon the heels of the steam-loom came the Jacquard machine. Mr. Ackroyd of Halifax was the first to try its powers, and in 1828 it had already won its way in the damask trade. Previously the patterns had been thrown up on the ordinary draw-loom, but a few manufacturers were partial to a local contrivance known as a "dobby" —a wooden machine placed across the warp to raise such threads as were needed to form diamonds and other simple figures popular for coat-linings. The value of the Jacquard, however, soon became apparent, and from its introduction may be dated the rise of the fancy goods trade of the district. The other eras in the progress of the stuff trade are no less sharply marked, although, in point of time, they were prior to the general adoption of the Jacquard machine. One of the most important of these eras was the year 1811, when moreens were first woven. There was within a few years of that date a fierce dispute regarding the real author of this class of stuff, and so sturdily was it maintained on both sides as to make it doubtful which was right. What might have been possible of determination then is quite impossible now; but the honour belongs either to James Ackroyd and Sons, of Brook House, or John Holland of Stead House, near Halifax. The other great era—prior to 1840—was that which marks the introduction of "plainbacks." Fortunately there is no doubt as to the originator of this novelty; and as it was the forerunner of merino—one of the staple articles of industry of the district now—its importance is beyond doubt. The first plainbacks were brought into the market in 1813, by the Messrs. Ackroyd, who have held a prominent position in this class of texture, and the merino which was naturally suggested by it, ever since.

Shortly before 1825 immense strides were made in the improvement of machinery, especially in the spinning frames. Up to that time long wool alone could be combed and spun satisfactorily. Every effort was made to increase the facilities for dealing with shorter staples, but it was not till the substitution of the "dead" for the "fly" spindle—an American invention, we believe—that the thing became fairly practicable; and the new spindle was not in general use in the Bradford district till about 1832. Attempts had been made, with some success, to mix medium-length staple with the long wools of Lincoln and Leicestershire, and in 1827 the first small parcel of Australian wool was tried by a Bradford spinner—Mr. John Wood, of the firm of Wood and Walker—and by the aid of the dead spindle it was found to be perfectly capable of successful manipulation. In a very few years the influx of this useful class of wool consequently rose from zero to several million pounds per annum.

Prior to the introduction and general adoption of mechanical aid in the fabrication of worsted textures, Bradford, as has already been said, was chiefly concerned in preparing and weaving this class of material. For example, at the beginning of the present century there were but two dyers in the town and neighbourhood—"The Bowling Dye Works" and the establishment in Silsbridge Lane, so long and honourably connected with the name of Mr. Peile. In consequence a considerable amount of profit and a good deal of work was diverted from the town. When goods had to be sent to a distance to be dyed, the cost of production was naturally augmented, and the profits of the manufacturers diminished; and it says much for the ingenuity of these men that they were able, notwithstanding that and other drawbacks, not only to hold their own, but continually to advance. In the case of goods, too, which before being sent to the consumer had to be finished by receiving a glossy surface, Bradford was for years obliged to

send work out of the town; but here, as in the matter of dyeing, the necessity of reducing cost soon wrought a radical cure, and for nearly thirty years there have been within the boundaries of the borough a complete range of machinery and skilled labour, enabling manufacturers to gain all the advantages of the cheapest and most satisfactory processes at their own doors for transforming crude fleece into the finished and marketable commodity.

POTTERY AND PORCELAIN.—VIII.

MESSRS. WEDGWOOD'S WORKS—PORCELAIN, ITS COMPOSITION AND DECORATION: THE CLOSE OF WEDGWOOD'S LIFE.

BY JAMES FRANCIS MCCARTHY.

INSIDE, Messrs. Wedgwood's works at Etruria present a quaint and old-fashioned appearance. With the exception of an addition to the premises, which was made some sixty years ago, in order to keep pace with the increasing demands for Wedgwood's pottery, the manufactory is precisely the same as when Josiah Wedgwood, in the fulness of his power, directed the industrial forces with which he produced perfect and beautiful work. Nearly all the shops are somewhat small and low-roofed, with raftered ceilings and little square-paned windows, through which the light comes faintly, as it did more than a hundred years ago. The lodge and the offices are the same, so are the entrances to the various shops, and the paths that lead from one department to another. Even the addition to the building, which has been mentioned, is strictly in harmony, as regards its architectural construction, with the works as originally established; and, therefore, the whole place as distinguished from the prominent and obtrusive manufactories of the nineteenth century, has a venerable appearance, which, in connection with its famous associations, is singularly felicitous. The manufactory covers nearly seven acres of land, and the average number of persons employed—including artists, potters, clerks, and labourers—is between six and seven hundred. The amount of work which is capable of being produced at Etruria may be judged by the fact that there are fourteen ovens, five for "biscuit," and nine devoted to "glost" firing. The three great-grandsons of Josiah Wedgwood—Mr. Godfrey Wedgwood, Mr. Clement Francis Wedgwood, and Mr. Lawrence Wedgwood—conduct the business. Besides the manufacture of jasper ware, parian, exquisite medallions, high class earthenware, and ornamental pottery, the firm have re-commenced the production of porcelain or china ware. We shall presently see how this description of the potter's art is made.

It must be borne in mind that there are two kinds of porcelain, hard and soft, which are very dissimilar in their component natures. The former, as its name indicates, is hard, has a fine grain, is compact, brittle, and faintly translucent. Tender porcelain, on the other hand, is soft in its composition, even after firing, is less fusible, and is opaque. From hard porcelain is principally produced what may be termed useful china—china, that is, which may be seen any day on the breakfast, dinner, or tea table. With soft or tender porcelain we get articles of ornament, delicate in their nature, like many rare works of art, but marvellously perfect in construction, faultless in their workmanship, exquisitely ornamented, and, as a consequence, proportionately costly. The plastic clay from which hard porcelain is manufactured, in many respects is like that used for earthenware. For instance, it contains a considerable amount of natural clay. The best English hard porcelain is made from a judicious combination of Cornish and Devonshire china clay, ground flint, ground Cornish stone, and calcined and pulverised bones. In addition to these compositions, chemical ingredients are introduced in a ratio which is never consistent, for the simple reason that each manufacturer, in order to realise the required result, has different ideas of their exact proportions. All superior porcelain has an extremely white appearance, an effect which is produced, and never permitted to be even partially lost by the most intense firing, in consequence of the clay containing a certain amount of silica. The Sèvres hard porcelain, of which we see and hear so much, and in which we all recognise and acknowledge a surpassing and inimitable loveliness, is largely composed of "kaolin," or china clay, with admixtures of decomposed felspar rock (very much like the Cornwall china clay), and Cornish stone. For tender porcelain the qualities of opaqueness and diminished powers of fusibility

are obtained by what is known as a vitreous "frit," caused by an addition of white marl or bone ash. The "frit" is reduced to a pasty fusion, is then pulverised, and to every third part one part of the white marl of Argenteuil is added. As may be apparent even to those who are not familiar with this industry, this paste is not very tenacious, and can only be worked in connection with some other composition; in this instance the paste is blended with a mucilage of gum or black soap. This gives plasticity, but even then the substance is so very soft that it cannot, like other kinds of clay, be fashioned by means of the lathe, but invariably has to receive shape and proportion in the "press" in plaster of Paris casts. The "slip" from which both kinds of plastic clay, for soft and hard porcelain, is made is produced in almost precisely the same way and by the same kind of machinery which was described in the first chapter. That which makes porcelain so much dearer than ordinary earthenware, is that its manufacture requires more laborious and delicate processes. It requires more skill, and therefore the labour which produces it is more expensive. Moreover, the firing needs a greater consumption of fuel as well as extraordinary care and vigilance, on the part of those whose duty it is to see that this heat is regulated with almost mathematical precision. Whilst all these exceptional conditions equally influence the manufacture of both kinds of porcelain, in the case of soft china, it must be remembered, the purely manipulative processes take a much longer time. And after the first firing, soft porcelain leaves more refuse than other descriptions of earthenware, because it is more liable to split and be fissured whilst in the biscuit kiln; therefore what is perfect after this ordeal is relatively of increased value. The mechanical operations used in the production of porcelain as compared with earthenware do not materially differ.

The processes of throwing, casting, and moulding, which have been explained before, are used for both kinds of ware. With regard to round plates and dishes made of porcelain, there is just this difference: they are never thrown, but are "batted" out from a block of clay placed upon a revolving disc, whilst the workman proportions the clay on the lathe. How delicate much of this work is may be imagined, when it is calculated that at the Sèvres manufactory a good workman makes no more than from fifteen to twenty pieces in a day; whereas the English potter, with the aid of two boys, can produce as many as 1,200 plates of earthenware in the same time. When the articles in porcelain have received shape they are taken to the kiln for the biscuit firing. This kiln is in form like that used for burning earthenware articles; and is usually about fourteen feet in diameter. The "seggars" containing the articles are of various shapes to suit the proportions of the ware which, whilst they shield it from the direct and consuming action of the fire, do not retard its indirect influence. Each china plate requires its own seggar, and its own bed. For this purpose calcined flint is used, because, as it is pure silica, it has no melting properties, and will not adhere to the china. The surface, too, must be perfectly flat and smooth, otherwise when the ware was cooling, irregularities and blemishes would be reproduced. Lest the firing should be too severe, "test cups" are placed in certain parts of the kiln where they can be seen by the watchers, and the varying degrees of heat can be ascertained by their appearance. The firing invariably lasts about forty-six hours; and for the oven to cool it generally takes from two to three days. In its "biscuit" state the ware is perfectly translucent, creamy-white, and vitreous. Afterwards the ware is taken to the dipping room and glazed. This glaze, which forms a glassy surface, is a chemical preparation consisting of borax, lead, flint, and other chemical ingredients. It is not necessarily white in colour, but partakes of several shades. For instance, the famous Wedgwood Queen Charlotte ware possesses a glaze of a delicate ivory-creamy tint: the decoration upon which always appears to be more beautiful by reason of the lovely surface which it covers. The glaze is applied by being rapidly dipped into large tubs which contain it in its liquid form. When the ware has been treated in this way it is once more burnt—this time in the "glost" kiln. This oven does not materially differ in construction from the biscuit kiln; but the firing is much more excessive. Each piece of porcelain is carefully separated as it is placed in the seggar, and the latter are piled up in columnar form in the immense kiln. The heat which has to be maintained to transfix this glaze to the body of the ware is something exceptionally terrific. During the last fifteen of the thirty hours before this burning work is thoroughly completed, the interior of the oven glows white with the intense heat—so intense, indeed, that the test cups can hardly be distinguished by the men who are watching the progress of the fire. And yet the seggars and their almost priceless contents remain intact under 2,500 degrees Fahrenheit! For three or four days the

ware is allowed to cool, and after being examined for possible defects, passes into the hands of the decorators and ornamenters.

The decoration of porcelain, calling forth, as it does, the highest skill as well as the most treasured fancies of the artist, is almost infinite in its ever-changing forms. As a pleasant stretch of landscape under varying conditions of light and shade, and with the changing moods of the seasons, is never exactly alike to those who behold it, but is constantly revealing fresh glimpses of beauty fleeting as they are unexpected; so also, in its highest forms, is the decoration of porcelain as constantly disclosing new phases of its loveliness. And with this difference: that whilst the sunniest pictures of nature are for ever fading and leaving in the memory only half-sad recollections, the poet's and the artist's ideas, whether they reproduce fair scenery or an inspired fancy, with the aid of a few skilful touches of colour, and the kindly action of fire, are imperishably realised. It is pleasant to watch these porcelain decorators professionally employed. Here, in one of these old-fashioned rooms of the olden time, sit a group of artists in the midst of their work. Much of the ornamentation is plain, consisting as it does of simply painting the white-glazed surface with any desired colour. This is done by placing the colour on in a pulverised condition with certain adhesive chemical preparations. The fire gives it tenacity. Then there is the gilding in gold, which, in elaborately and finely executed patterns, is all traced by the hand, and a very cunning hand it must be too. The gold used for this purpose is the purest that can be obtained, and as supplied to the patterns does not look like gold at all, but does resemble very closely grains of ground coffee. The colours which are used by the artists are all made from metallic oxides. For instance, copper gives a green and black colour; cobalt, blue; gold, purple; iron, red; and so on. The colours are mixed with oils and other ingredients, and are placed at the disposal of the painters. This preparation of the colours is one of the most dearly-prized arts in connection with this wonderful industry. The judicious and skilful blending of these colours, so that when they are burnt in they shall enrich and beautify the ware which receives them, will

ETRURIA WORKS.

sometimes make the fortune of a firm; as, on the other hand, the unskilful mixing of them will mar the hopes of the manufacturer, and disappoint the fond wishes of the artist. As a rule, the managers of the works undertake this task; and it is scarcely necessary to say that it is one which is often attended with anxious and costly experiment before success can be ensured. The painters have before them a complete set, composing a miniature tea service for royalty. The tray itself is of pure porcelain: the surface richly and thickly inlaid with gold. In this gold some wonderful tracery of figures, very much like chasing on gold itself, is made. But the effects with colours are more remarkable still. One of the artists—and they are all specially trained for this kind of work—picks up a cup as thin as an egg-shell, of beautiful white glaze; and with his camel-hair pencil begins to weave his fanciful designs, already slightly traced. Quickly the painting brush picks up a little colour, which is traced on the surface, and as quickly the outline of some design—conventional, classical, or natural — begins to appear. The colours as yet are all dusky and dingy in appearance, but, nevertheless, we see the outline: it is a setting of flowers, of daisies and roses and drooping lilies, of tender leaves with russet hues. We see all this after the article has been burnt in the "muffle," of which we have before spoken. Then it is noticed how the artist who appeared to work so mechanically has also worked with such intelligent grace and beauty; and that the apparent easiness of effort was the ease which long training and culture give. Then, again, how exquisitely another artist is rendering a sunny sketch of nature: quietly and swiftly the brush moves over the surface in dingy patches; but in a few short hours afterwards, when the fire has fiercely wrung from these metallic oxides all their glowing virtues, what a picture we have. It is nature photographed in colours: from the slender blades of grass, through which here and there a daisy modestly peeps, to the leafy trees and the sky with silvery clouds above, all is pictured with marvellous realism. There is not a shade wanting: nor a vein in any of the leaves to mar the uniform precision of the view. As to figure painting, it is endless in its variety as it is truthful in its conception. The figures are first of all feebly sketched on the glazed surface, and then the artist begins his delightful work; and when it is finished—after it has left the fire, of course—we see features familiar to us, perhaps either in classic story, in the inspiriting annals of history, or as the unconscious realisation of a pleasant fancy. Bearing in mind the degree of art which is achieved in this painting, it is done with surprising rapidity. Of course, very high-priced sets of porcelain—and Messrs. Wedgwood not long since furnished a set of about seven pieces which were worth more than £300—take days, weeks, and even months before the painting is finished. The firing afterwards requires an almost incredible amount of care and precaution.

The Etruria Works were opened on the 13th of June, 1769; an event which was commemorated by Josiah Wedgwood "throwing" six Etruscan vases. As the master-hand fashioned the soft clay into incomparable beauty of outline, Bentley, of refined taste, on this occasion performed the mechanical duty of turning the potter's wheel. It is pleasant to recall this incident. Two great men working in such perfect harmony, that whilst one, the greater, weaves for the delight of future generations beauteousness of form out of a simple piece of soft clay, the other, his partner, companion, dear friend, and steadfast guide—a man of learning and taste, with the graceful and easy manners of a gentleman, and with a true gentleman's innate tenderness of heart—willingly does the simple duty of a potter's boy. In Bentley's case the turning of the potter's wheel was no lowly labour. Those who work in peaceable company with great men—whether the greatness is the power of intellect or the mighty force of skilled and never-tiring labour—in some measure contribute to and participate in the enduring results which are achieved. In 1774, the Etruria Works were finished. Shortly afterwards the famous service, consisting of 365 pieces, was specially made for the Emperor of Russia. As a piece of ornamental pottery, it was, and is, unique. Each piece of the service presents some lovely spot of English scenery—scenery of that quiet, gentle, and homely nature, of which Mrs. Hemans has so often reminded us by the sweet force of her poetry, and which this land of ours alone seems to possess. Two years later—in 1776—we find at work the great Flaxman, called by Josiah Wedgwood the "genius of sculpture." From this time commenced the production of cameos, vases, and tablets enriched by the perfect modelling skill of Flaxman. He ornamented the ware in a purely classical manner. Pages might be written of the beauty of his work. But there are some productions too great for ordinary praise; we feel their influence and the power that produced them; and we know that

words can never fairly gauge the strength of genius. In 1780, as afterwards, the business prospered, and many catalogues of Wedgwood's ware were issued. In this year Bentley died—died suddenly too, before Wedgwood had the chance of hearing even a last word from one who for many years had been his great co-worker. This event much affected Wedgwood, who thereafter ceased to make with his own hands works of pottery from soft clay, but manifested a warm interest in science and politics. He died, in 1795—where he had spent the greater part of his life, and performed all his great active work—at Etruria. He died not as many illustrious men have done, in the sad decadence of their strength, and with the unutterable consciousness of power ebbing away like life itself, but in the meridian of his fame and might, with no faculty impaired, and with his mind cheerful and lucid to the last. His body was buried in the parish church at Stoke-on-Trent, near the very heart of the field of labour which he so widely enlarged. To perpetuate his memory an institute was opened by Mr. Gladstone at Burslem; and those who journey into North Staffordshire and alight at the busy Stoke-on-Trent station, as they leave the platform, and walk into the open street, will see the familiar monument of Josiah Wedgwood. It is a statue charmingly and cunningly worked by the sculptor. There is the dignified form, the earnest face, betokening great strength of will and resolute power—all wonderfully reproduced by the artist. The figure of Josiah Wedgwood stands erect, and in one hand he holds a vase, which, as the appropriate fancy of the sculptor plainly suggests, has just been fashioned by him. This is how all who knew Wedgwood, and all who have seen and admired his great works of art, love to picture him; and as the dusky carved figure of this prince of labourers stands there in the midst of the stirring bustle of daily working life, all those who see it or cross its shadow, must needs think, if only for a few moments, in admiring reverence of Josiah Wedgwood.

SHIP BUILDING.—XXVI.

IRONCLAD RECONSTRUCTIONS OF THE NAVY.

PRIOR to the introduction of steam-ships, the changes in war-ship construction had been few and gradual; but during the last half-century one reconstruction has followed close upon the heels of another, and our naval architects have known no rest. In a previous chapter we have sketched the early history of steam shipping in the Royal Navy, and described how the success attending the use of paddle-wheel tugs and mail-packets, led to the building of larger paddle-wheel steamers, armed and equipped for fighting. The period from 1821 to 1843 was thus occupied, but at its end no paddle-steamer larger than a frigate had been built, and our line-of-battle ships were still wholly dependent upon sails for their propulsion. This was the condition of foreign navies as well as of the Royal Navy, and it is not surprising, when one considers the serious objections that could be urged against the use of paddle-wheels in the larger classes of men-of-war. In paddle-wheel steamers the propelling apparatus was necessarily much exposed to damage by artillery fire; the central part of the ships was occupied by the machinery for driving the paddles, and comparatively few guns could be mounted in proportion to the tonnage of the ships; and furthermore, such vessels were never found to perform well under sail alone, the paddles causing a great "drag" in the water. Consequently, although the value of the paddle-steamers to the fleet was fully recognised—especially as regards the assistance they could render by towing the sailing line-of-battle ships into position—they were never regarded as substitutes for the larger sailing ships. Nor did the sailor wish to see the graceful sailing ships give place to steamers; and it is not difficult to imagine the satisfaction with which the veterans of the great French war saw the keels of two and three-deckers of the old type being laid thirty years after that war had ended. All this was changed, however, when the screw-propeller had been proved efficient by its trials in the *Archimedes*, the *Great Britain*, and the *Rattler*. The last-named ship was launched in 1843, her trials extended over the following year, and in 1845 the Admiralty began the extensive construction of screw steamers.

At first the application of the new propeller was limited to frigates, and to the so-called

"block-ships," especially designed for coast defence. The latter vessels were "converted" from sailing ships, and some of them were from thirty-five to forty years old before they were turned into steamers. Judged by present standards the block-ships were very slow and inefficient, but they proved of great value during the Crimean war. This commencement of a new era in construction was not, however, marked by decision and rapid progress. In fact, several two and three-decked sailing ships were begun during the period 1845–50, and not a single screw line-of-battle ship was laid down until 1849, when the *Agamemnon* was begun—the vessel which afterwards became famous for her services in laying the first Atlantic telegraph cable. It would be idle to discuss the reasons for this hesitancy on the part of our naval authorities, but their action was soon influenced by that of the French. They were not slow to profit by the experience gained in England with the screw-propeller, and as early as 1847 they decided to construct screw line-of-battle ships, having good sail-spread, full armament, and relatively high speed under steam. The first completed ship of the new class was the *Napoleon*—a worthy rival of our *Agamemnon*—both of these vessels having been tried in 1852. Their success was complete, and from that time onwards there could be no doubt that sailing ships of war were doomed. The Crimean war furnished further evidence of the superiority of screw-steamers, and from 1852 to 1860 our dockyards were busied in the conversion of sailing ships into screws, or the construction of new steamers. The process of conversion extended from three-deckers down to frigates. Vessels were cut in two amidships, and the separated parts were pulled asunder, the space being afterwards built in, to give additional length. Lengthening by the bow or by the stern was also common, and in not a few cases three-decked sailing ships were turned into two-decked screws. At the close of the Crimean war, in 1856, the Royal Navy is said to have contained 140 screw steamers, built and building, exclusive of gunboats, and thirty paddle-steamers. Three years later (in October, 1859), the corresponding number of screw-steamers was about 170, including only those vessels from sloops up to three-deckers. During the year 1859, no less than seventeen line-of-battle ships and ten frigates were launched or had their conversion completed, while twelve line-of-battle ships and thirteen frigates were in hand. This is good evidence of the energy with which the steam reconstruction of the Navy was then being pushed on; but, unfortunately, a further reconstruction had already become necessary. The days of unarmoured battleships were numbered, and much of the work done during the period 1857–9 was consequently wasted.

Before attempting to describe the ironclad reconstruction of the Navy, it will be proper to mention the features in which the screw surpasses the paddle as a propeller for war-ships. First, it will be noted that the screw is submerged at the stern of a ship, and therefore is much less liable to serious damage than the paddle-wheel, which is also far more complex in its structure than the screw. Second, with screw-propellers the engines and boilers can be placed low down in the hold of a ship, beneath the level of the water, and be much better protected than paddle-engines can be. Third, in vessels designed for sailing as well as steaming, like the unarmoured war-ships, it was usual to fit the screws in such a manner that they could be hoisted inboard when the sails were set, the vessels being relieved of any "drag" from the propellers. Furthermore, there was no obstruction in the screw-steamer to the use of a full battery of broadside guns, like that of the sailing line-of-battle ships. In later years, some of these features of superiority in the screw-propeller have become of less importance, efficiency under sail having been purposely reduced, at least in the larger classes of ships. But up to 1860, good sailing qualities were considered essential in all classes of ships, and it was usual to speak of the steam-power as "auxiliary" even in ships where it was of very considerable amount. At present, the cruisers of the Royal Navy designed for long periods of service on distant stations, very closely resemble the types in vogue twenty years ago, in so far as the possession of good sail-power is concerned. Progress in marine engineering has, however, rendered possible large economies of coal, and added to the distances over which these, as well as other vessels, can proceed under steam alone. Sail-power has consequently lost something of its value, and in many classes of war-ships it is now only auxiliary to the steam-power, while in some classes it is altogether wanting.

One necessary result of the addition of steam power to her Majesty's ships, was an increase in their size and cost. For example, the largest sailing three-deckers were only about 200 feet long, 54 feet broad, and weighed 4,700 tons when fully stored and equipped. The corresponding class of screw line-of-battle ships, built just before the first ironclads were laid down, were 260 feet long, 60 feet broad, and weighed nearly 7,000 tons. The

increase in dimensions chiefly resulted from the weights of machinery, boilers, and coals, that were carried, and the adoption of a greater ratio of length to breadth was a consequence of the use of steam-power. For sailing ships moderate length and comparative fulness of form could be accepted and were indeed preferred; such proportions favouring handiness and sail-carrying power. In structural arrangements and armament the screw-steamers closely resembled their predecessors. Wood was the material used for the hulls, and the guns were ranged along the broadside in one, two or three tiers, according to the class of the ship. A first-rate, or screw three-decker of 1859, carried about 120 guns, was manned by a crew of about 1,000 officers and men, and cost nearly a quarter of a million sterling, exclusive of her armament. Such was the type which only thirty years ago seemed the fullest embodiment of naval force. Towering high above water, with graceful outlines, tall, tapering spars, and numerous ports, from each of which peeped a gun-muzzle—such a vessel could not fail to impress the spectator more favourably than the raft-like "monitor" of the present day. The illustration on p. 21, Vol. I., will enable the reader to understand the contrast, but at Portsmouth or Plymouth he may study it more fully. Our grand unarmoured line-of-battle ships lie peacefully in the harbours which some of them have never quitted since they were launched, and their places are filled by the less magnificent, but far more powerful ironclads that now form the forefront of our naval strength.

The Crimean War not merely established the absolute necessity for steam-power in war-ships, but gave rise to the construction of ironclad ships. It will be long ere the so-called "massacre" of the Turkish fleet at Sinope is forgotten, and the lessons there enforced have produced wonderful results during the last quarter of a century. The Turkish ships, built of wood, like all other war-ships of that period, were destroyed by the fire from the shell-guns carried by the Russian ships. The shell-gun was no new invention, but had been in use for thirty years. Nor were its terrible powers against unprotected wood-built ships unknown, for General Paixhans, of the French service, who had much to do with the introduction of such guns, had clearly described how wood ships might be shattered or set on fire by the explosion of concussion shells, and suggested as a remedy the coating of the sides of wood ships with iron plates. General Paixhans' proposal was examined in France, but declared impracticable. In the United States it was adopted in principle by Mr. Stevens of New York, who secured a contract from the Government, and actually began to build an ironclad floating battery ten years before the Crimean war. Little was known in Europe of this undertaking, and no attempt was made to construct special classes of armoured vessels until 1854. The action at Sinope, and the injuries sustained by the allied fleets in their attacks on Sebastopol and other Russian fortifications, led to further consideration of the matter. The late Emperor of the French, Napoleon the Third, took the lead, and ordered the construction of the first European ironclads, the floating batteries which took part in the attack on Kinburn. Several similar floating batteries were also built in England about the same time, but they were not completed soon enough to be of service. The experience gained at Kinburn showed, however, that the 4½ inch iron plates with which the sides of the batteries were covered, were strong enough to resist the impact of the heaviest shot then in use, at very close ranges, and thus a protection originally devised against shell-fire, became useful against all kinds of projectiles. As their name implied, these batteries were really not designed for sea-going purposes; they were furnished with machinery sufficiently powerful to enable them to proceed at low speeds under their own steam, but they were unhandy and ill-behaved at sea, and sailors were inclined to argue from their performances, that armoured ships capable of keeping the sea in all weathers, were scarcely likely to be produced. This opinion was speedily shown to be mistaken by the hard logic of facts. The Emperor determined to proceed further, and called to his assistance M. Dupuy de Lôme, who had already attained distinction as the designer of the *Napoleon*, the first screw-liner built in France. Before the close of 1857, the design for *La Gloire*, an armoured frigate, was prepared, and in 1858, no less than three vessels of that class were on the stocks. It has been well remarked by a writer on this subject that "this was a bold experiment, but every means was taken to minimise the experimental features in the designs; and the result proved how, in default of experience, it may be possible to achieve success in new directions if only the attempt be made to accord with the well-established principles of science." Such an enterprise could not fail to attract attention in England, seeing that its success threatened our naval supremacy, to maintain which, by the steam-reconstruction of our fleet, strenuous exertions were

then being made. In fact, English naval architects had made proposals for the construction of ironclad ships two or three years before *La Gloire* was laid down, but their suggestions were not entertained, and it was not until May, 1859, that our first ironclad, the *Warrior*, was ordered to be built. Then began a series of rapid changes, consequent upon the battle of guns against armour, which are still in progress, and of which no one can predict the end.

Although only a historical interest now attaches to the comparison of *La Gloire* and the *Warrior*, it may be well to mention briefly their chief points of difference. M. Dupuy de Lôme in designing *La Gloire*, retained nearly the same under-water form and dimensions as had proved successful in the two-decker *Napoleon*. Above water, however, the ironclad had only one tier of guns, and this reduction effected a saving in weight sufficient to clothe the sides of the vessel throughout the length with armour about 4½ inches thick, from a depth of about five or six feet under water to the upper deck. The hull of *La Gloire* was of wood, and the armour was simply secured to the wood sides by screw bolts. It will be seen, therefore, that the novel features in the design were reduced to the minimum, consistent with the use of armour; and although sailors doubted the seaworthiness of a vessel so burdened on the upper works, naval architects were disposed to anticipate her success from the known performances of the unarmoured two-deckers which she resembled in so many features. Turning to the *Warrior* design, we find a totally different set of conditions. The ship was in all respects a departure from precedent, and was a bold experiment. Her length was 380 feet, and no other ship of war had previously been built for the Royal Navy exceeding 300 feet in length. Although she was styled a frigate, and carried all her guns in one tier, she was 30 per cent. heavier than the largest three-decker. Her hull was iron-built, her engines were of exceptional power, and her speed exceeded that of all preceding unarmoured war-ships. For about 200 feet at the centre of the length, the sides were protected as in *La Gloire* by 4½ inch armour, and transverse armoured bulkheads were built to enclose a battery, in which twenty of the heaviest guns then made were mounted. Before and abaft this battery, the ends of the ship were unprotected by armour, and the steering apparatus was exposed to risk of severe damage. This was the most serious fault in the design. It is but right to add that the designers of this noble vessel, for it was a grand production for the period, achieved a great and unqualified success. The intended speed was exceeded on trial; the vessel proved a good sea-boat and a fair performer under sail; of her structural strength there has never been any question, and the wisdom displayed in the use of an iron hull is now generally admitted. *La Gloire* still stands on the French *Liste de la Flotte*, but of her condition there can be no question, and it must be rather a matter of sentiment than of any capacity for further service that keeps her name on the list. Other wooden vessels of about the same date in both the French and the English Navies have fallen into decay, and been classed as unserviceable, while the *Warrior* is as sound and efficient as ever. Objections may be urged to many features in the design of the *Warrior*, in the light of subsequent experience. Her great length makes her comparatively unhandy in manœuvring, and the want of protection to her steering gear is to be deplored. In some respects she may indeed be termed obsolete, but she is undoubtedly a valuable adjunct to the fleet; and that policy must be commended which caused her to be so much more durable than her French rivals of the same date. The policy thus initiated has never been abandoned in England. Iron or steel has been used in the hulls of the greater number of our armoured ships. Wood hulls have been used in certain cases, but never with any hope of equalling iron. In 1861, for example, when there was something like a panic in this country at the lead which the French had obtained in ironclad ship-building, several of the screw unarmoured line-of-battle ships then on the stocks, were "converted" into ironclads of a type closely resembling *La Gloire*. A pressing need was thus met as quickly as possible, but the ships produced have already fallen into decay. In other cases, wood hulls have been used to utilise the large stores of timber that had been accumulated in the Royal Dockyards, when it was anticipated that wood ship-building would be continued. Here also the results have not been satisfactory as compared with those obtained in iron-built ships. Such exceptions bring into relief our general policy, and show how much more likely to endure is our ironclad fleet than that of France, where the use of wood hulls was persevered in for ten or twelve years after *La Gloire* was built. At present all maritime powers are following our lead, and building armoured ships of iron or steel, with structural arrangements closely approximating to English models.

IRON AND STEEL.—XXIV.

CUTLERY—FIRST PAPER: SHEFFIELD.

By Charles Hibbs.

SHEFFIELD has been so completely identified with the cutlery manufacture during a time which, as the law books have it, "the memory of man runneth not to the contrary," that no account of the trade itself would be acceptable which did not include a considerable reference to its ancient locality. It is one of those cases in which, from long association of ideas, the place and its productions seem to couple themselves naturally in our minds, and cannot be separated. Nottingham lace, Staffordshire pottery, Manchester cottons, Kidderminster carpets, Coventry ribbons, and many other specialities of the same kind, down to Burton ale and Cheshire cheese, are "familiar in our mouths as household words;" but Sheffield cutlery is the oldest and most familiar of them all. Everybody has read, or heard of, the allusions to "Sheffield whittles" in Chaucer's "Canterbury Tales." From that time to the present the excellence of the Sheffield blades has never been contested, and there is not a corner of the habitable globe, from a Parisian *salon* to a Kaffir kraal, where they are not to be found. The tables of all nations are laid with Sheffield ware. The delicate scissors of a lady's work-box, and the shears that clip the wool of Australian sheep; the exquisite instruments of surgery, and the axes that are to hack the ancient ice at the North Pole, are alike made by Sheffield. An English gentleman must have Sheffield razors in his dressing-case; a British tar will have none but a Sheffield jack-knife hanging from his belt. Does an English workman anywhere want a good cutting tool, it is on Sheffield he relies for it.

The peculiar topographical situation of Sheffield would alone entitle it to be regarded as one of the most remarkable manufacturing towns in the kingdom. Embosomed in a range of lofty hills and moorlands, which present to the traveller's eye a constant succession of picturesque surprises as he traverses them, the old town seems to be nestling in a hollow, its coverlid of black smoke resting closely upon it and around it. It looks in the distance like a huge black patch upon the landscape. From the recesses of the hills issue the four silver streams which are to become the tributaries of the good river Don. We can trace their course for many a mile, and see that, gathering volume as they proceed, they at length meet and mingle together in the heart of that clustering hive, which owes so much of its prosperity to their aid. One of them, the Sheaf, is said to have given the town its name, Sheaf-field—the field by the Sheaf; yet this would appear to be but mythical. Standing on one of these eminences, and looking down upon the dense and seething mass of human activity, with its modern accompaniments of smoke, and flame, and ceaseless roar, which now occupies the scene, one cannot help fancying how lovely must have been that valley in days gone by, when the dotted water-wheels but added features of picturesqueness to the landscape, and the lazy mill-clack seemed to harmonise so well with the music of the fields. A writer in the *Athenæum*, on the occasion of the visit of the British Association to the town in August, 1879, says:—"Built wholly of stone, standing in a thickly-wooded valley at the junction of five clear rivers, and boasting a great castle and a fair manor-house closed round by deer parks, Sheffield must once have been as picturesque a town as any in England; but now, with its woods cut and burned to smelt the iron they covered, its castle and manor-house razed, its water fouled, and its stone replaced by peculiarly dingy brick, it would perhaps be hard to find a more prosaic or a more unpleasant place." According to Macaulay, the era of its deterioration must have been early, for speaking of it as it was in the time of the Restoration, he says:—"Most of the Hallamshire forges were collected in a market town which had sprung up near the castle of the proprietor, and which, in the reign of James I., had been a singularly miserable place, containing about 2,000 inhabitants, of whom a third were half-starved and half-naked beggars. . . . The effects of a species of toil singularly unfavourable to the health and vigour of the human frame were at once discerned by every traveller. A large proportion of the people had distorted limbs." And besides these, the reader will not fail to be reminded of many allusions in contemporary literature to the dirtiness, the smokiness, and the general uncouthness of Sheffield and its people. But despite this consensus of unfavourable opinion, we venture to say that there is much in the present aspect of the town which is calculated to produce a favourable first impression

upon the spectator. On entering it from the railway it appears to be by no means wanting in features of striking interest. The noble river flowing at its foot, bounded on one side by the long black walls of some stupendous "works," with furnaces that cast a lurid light upon the water, and on the other by quays and wharfs busy with traffic, and a fine broad elevated thoroughfare leading right into the heart of the hilly town, is the first picture that meets the eye. Before the spectator lies a vast irregular panorama of brick, and a forest of towers, and spires, and chimneys, backed up and enclosed by a range of hills that form a great natural amphitheatre. Grimy and uninteresting as the town itself is said to be, it is yet far superior in many of its features now to the metropolis in the days of which Macaulay wrote; and though it may unfavourably compare with other towns of younger growth in its urban arrangements, there is no town in the kingdom which has finer suburbs, or more places of beauty and interest within its immediate reach.

Like most ancient seats of industry, Sheffield seems inclined to claim a higher antiquity than properly belongs to it. Local historians have said that Sheffield cutlery was not unknown at the time of the Romans; but the fact is, we believe, that no evidences have been found of any Roman occupation in the vicinity. If that wonderful people ever did effect a settlement in the bosom of the Yorkshire hills, they have, strange to say, left no trace behind them. In Domesday book, Sheffield, then called *Escafelt*, is spoken of as a manor held by Roger de Busli, and it was a lord of that family who, in 1160, granted a licence to the inhabitants to dig and smelt iron ore. This was, doubtless, the beginning of its industrial history. Abundant veins of the useful mineral were discovered; and what was quite as much to the purpose in those days, there were plenty of trees to cut down and use for fuel. Under the most primitive conditions, with quaint old-world simplicities and contrivances, the stalwart Yorkshire dalesmen made a name for themselves and their wares, so that a "Sheffield thwytel" was thought worthy of celebration by the father of English poetry, and Sheffield arrowheads were prized by the archers who fought and won at Crecy and Agincourt. The records of this period of its history are but scanty; but it is generally supposed that little progress was made for about three centuries, which "langour," says Macaulay, "may perhaps be explained by the fact that the trade was, during the whole of this long period, subject to such regulations as the lord and his court-leet thought fit to impose." Nevertheless, Hunter describes it as being in the 16th century "a thriving manufacturing town, in the centre of a manufacturing district." About the year 1570 occurred the great immigration to this country of artificers from the Netherlands, whence they had been driven by the merciless persecution of the Duke of Alva. They fled for protection to our own good Queen Bess, and she, acting on the advice of her Lord Chamberlain, the Earl of Shrewsbury, drafted them off to various parts of the kingdom, where their skill could be best turned to account. We, of this 19th century, who are a little too apt to boast of our manufacturing supremacy, perhaps forget how much of it we owe to this and other introductions of foreign new blood. Hunter, the historian of Hallamshire, says in relation to this event:—"All, or the greater part of those who were artificers in iron, were sent to the Earl's own estate in Yorkshire, and hence we may date the first improvement in Sheffield cutlery. Now began to be made spears, sickles, knives of various kinds, and scissors, the manufacturers of each article confining themselves to some particular village, which arrangement, to a great measure, continues to this day."

The new and sudden access of prosperity thus brought about was attended with a result too common to cause much surprise, viz., the introduction to the market of inferior goods by unscrupulous makers, who took advantage of the reputation which the town had acquired to palm off their worthless imitations. To such an extent was this carried, that the character of Sheffield cutlery was markedly lowered, and the demand fell off considerably. Representation was made to Parliament that "deceitful and unworkmanly wares" were being made and vended by "divers persons who refused to submit themselves to any order, ordinance, or search." The outcome of the agitation was the establishment of the once powerful and still famous *Cutlers' Company*, which received its charter of incorporation in 1624, the 21st year of the reign of James I. The preamble of this Act shows very clearly how important the trade had now become:—"Whereas the greatest part of the inhabitants of the lordship of Hallamshire in the county of York, do consist of cutlers, and those who make knives and other cutlery wares, made and wrought of iron and steel, as sickles, scissors, and shears, and by their industry have not only gained a reputation of great skill and dexterity in the said faculty, but have relieved and

maintained their families, and have been enabled to set on work many poor men inhabiting thereabouts, who have very small means or maintenance other than by their hands and daily labour, as workmen to the said cutlers, and have made knives *of the best edge*, wherewith they have *served the most part of the kingdom and other countries till now*," &c.

The rules of this company were said to be "agreed upon by the whole fellowshippe of cutlers," and it had power, amongst other things, to grant *marks* to the manufacturers of all cutlery wares. Sheffield has always been the very metropolis and head-quarters of trade marks. Every maker has his own particular symbol; and many of those now in use, and best known, were granted by the Worshipful Company of Cutlers. The ancient functions of the company have long fallen into desuetude, and now, its principal duty seems to be the holding of the annual venison feast, when the Master Cutler entertains his guests in state, much in the same way as the Lord Mayor entertains her Majesty's Ministers on the 9th of November.

Singularly enough, while the steel wares of Sheffield were thus attaining world-wide celebrity, little or no attempt had been made to produce the steel itself, which was mostly imported from Germany. At the commencement of the 17th century, there were only two small furnaces at work, where now there are probably more than two hundred. The production of the very finest qualities of steel is now one of the specialities of Sheffield, and has been, without doubt, the foundation of its present prosperity. Its annual trade in steel alone is estimated to exceed £3,000,000. One great advantage has been that it could produce at its own works the exact standards of steel necessary to suit the various purposes for which steel implements were required —quite as important a matter as their shape or fashion. The finest cutting instruments of all kinds, as also engineers' tools, and many articles which require to keep a good edge under trying circumstances, are now made of *cast steel*, and it was the invention of cast steel that marked undoubtedly the most momentous epoch in the history of Sheffield. The different methods of producing steel by cementation, from "blister," or "common," to

GRINDERS AT WORK IN A "WHEEL."

"cast," and the somewhat romantic manner in which the secret of the latter process was made known, have already been related in this work (Vol. I., pp. 276—9), and we shall in this and following chapters speak of the subject only as it bears immediately on the cutlery trades of Sheffield. Thus, there is a quality known as *shear* steel, which is produced by welding together several pieces of common steel, with the view principally of getting a perfectly homogeneous substance throughout. This process is called *shearing*, by an odd connection of ideas. Mr. George Dodd remarks:—"When we see 'shear steel' stamped on table knives, we may not inaptly imagine that it is steel which has been cut with a pair of shears; but the connection is more remote. This steel, soon after its introduction, being found suitable for making shears, it obtained the name of shear-steel, and by another step in the same road, the process came at length to be called shearing; a name about as consistent as it would be to apply the term *shoeing* to the process of tanning a calf-skin, on the ground that it makes leather fit for shoes." Odder still, the process of advancing this steel another stage, and making it suitable for quite another class of goods, is called *double shearing*, and the steel is known as *double shear*. Many other instances of eccentric nomenclature will crop up in the course of our remarks.

The modern progress of Sheffield may be estimated by the rapid increase of its population. Macaulay says that it did not amount to 4,000 in 1765. In 1801, it had risen to 45,000; in 1851, to 135,000; and in 1881, to nearly 285,000. Of course, this must not all be set down to the credit of the cutlery manufacture, as in late years many other important industries have sprung up, and employ a large percentage of the people. Among these, the armour-plate works of John Brown and Co. will be readily called to mind. Sheffield makes almost everything in iron and steel, and some things besides cutlery may be said to be specialities of the place—as anvils, vices, stoves, grates, fenders, and other classes of heavy goods. It also enjoys a considerable reputation for electro-plated wares. But the manufacture of "all manner of cuttynge tools," including saws, files, planes, scythes, &c., is still the staple of the ancient lordship of Hallamshire.

Reserving points of detail for another chapter, we may remark that the general conditions of the trade have altered very little within the last generation. Few points of novelty are presented, and no new and startling departures, such as have revolutionised other trades, have occurred in this. Sheffield cutlery has taken the lead, and kept it, not by any development of the factory system, or wholesale introduction of machinery, but by the simple means of putting the best workmanship on the best materials. Nowhere perhaps in the kingdom are the ideas of masters and workpeople more conservative than they are here. The old methods are universally regarded as the best, and no new-fangled notions are supposed to have any chance against special knowledge and skill of hand and eye. Manufacturers have their own particular ways and trade secrets, which they guard jealously from observation; workmen hand down their little handicraft knacks from father to son. The visitor to a cutler's shop (*see* FRONTISPIECE) will see nothing striking or wonderful, only a few workmen filing, hammering, drilling, and fitting parts together, with a deftness and quickness which only long practice, aided by hereditary aptitude, could give. The tools they use are simple and old-fashioned; the shop is meagre in all appliances and aids to labour; their own manner shows surly independence and reserve. There is nothing to see: if you want to find out how those brilliant results that you have seen in the show-case are brought about, you must look for the secret in the workman's fingers—there is nothing else. They say they have that in their fingers which makes them independent of anybody, and which nobody can take from them. A Sheffield artisan is very proud of his craft; he guards its rights and privileges with great care, and is jealous of all intrusion or interference. Nowhere has Trades' Unionism been more rampant, or shown more ugly manifestations. The worst features of this system have now happily all but disappeared; but the ideas of clan and trade-guild remain in full force. Doubtless this acts prejudicially in the way of barring improvements, or ready adaptations to new demands; and the trade has more than once suffered through unwillingness to accommodate itself to the requirements of foreign markets; but it is something to have maintained the old standard of excellence through all the excitements and allurements of competition; and this, it is fair to admit, has been secured mainly by that very trade conservatism which is otherwise so open to objection.

Many evidences remain of the manner in which Sheffield has been aided by her natural advantages of position. Mills are still turned extensively by water-power. The "five clear rivers"—the Sheaf, the Porter, the Loxley, the Rivelin, the Don—

names dear to every Sheffielder, still do good service in making wealth for the old town. In former times, grinding mills were invariably set in motion by a water-wheel; and so, with true Sheffield perversity of designation, the mill itself got to be called a "wheel," and is so to this day. Two things extensively prevail at Sheffield—division of labour and *out-work*. The out-worker takes out his work from the warehouse, performs his one operation upon it at home, or in a shop or stand which he rents for the purpose, and returns it, being paid by the dozen, or gross, or score, as the case may be. In like manner, the grinder, who may be a file-grinder, a saw-grinder, a scissor-grinder, or what not, hires a seat and "power" at a "wheel," and works for the trade. The illustration accompanying this chapter shows a portion of the interior of one of these "wheels."

INDUSTRIAL ART.—VII.

ART IN TEXTILES.—SECOND PAPER.

By John Forbes-Robertson, Author of "The Great Painters of Christendom."

IN speaking further of carpets, curtains, dresses, or any of those textiles, from gold and silver to hemp and cocoa-nut fibre, into which design and colour enter, we would summarise those general art-principles which from time to time we have expounded in these chapters, in the following way.

Let the designer have a thorough knowledge of the characteristics of styles—that is, the leading types of art, the recognised standards which come to us with the sanction of ages,—of how the Egyptians, for example, turned to decorative account the scarabæus or beetle, and the lotus or water-lily of the Nile; the Greeks, the horse-chestnut, the honeysuckle, and the acanthus; and the Chinese, the hawthorn, the chrysanthemum, and the peach. But not only did the ancients introduce into their decoration objects which were symbolic, mythic, or legendary, in their reference, they were able, also, to utilise the written characters of their languages, and by their arrangement, make them at once ornamental and explanatory. The Egyptians and the Chinese are more especially alluded to; but it is well known, also, that many of the letters of the Greek alphabet—especially the gamma (Γ)—were largely used by the mediæval and early Christians in giving pious symbolism and beauty to their altar-cloths and ecclesiastical garments. By a combination of two or four of these gammas almost any variety of cross could be formed. Indeed, there is scarcely a letter in the Greek alphabet which has not been used decoratively in the service of the Church. Even historic incidents were sometimes turned to artistic account by Pagan, as well as by Christian, peoples; for, according to Du Serres, as quoted by the quaint, scholarly, and incisive Doctor Thomas Fuller in his "Holy War," the Saracens, in perpetual memory of their having recovered Damietta, wrought in the borders of their tapestry a wafer-cake and a box—St. Louis on his liberation from captivity having pawned the pyx and the host as security for the money he owed his Egyptian conquerors.

The pine, again, has been conventionalised into the famous shawl pattern of Cashmere, which our Paisley weavers imitated so admirably, and produced what in our eye is one of the most comely garments a woman can wear; although, in its conversion to decorative purposes it has almost lost its identity, and to an irreverent imagination has as much the look of a magnified flea as of a pine, still its form and flow of line are particularly grateful to the eye, and the whole world has not only accepted the pattern, but pronounced it beautiful exceedingly. It ought to be mentioned here, however, that Eastern travellers tell us that the pine-pattern of Cashmerian looms has nothing to do with the pine, and is only a conventionalised imitation of the curves of the river Jhelum, which, as seen from the ancient temple which crowns the steep rocky hill called the *Throne of Solomon*, leads the eye lovingly along its silvery windings, much in the same way as the "Links of Forth" guide the gaze of him who beholds their beauty from the historic heights of Stirling. In either case the adaptation is from Nature.

The conventional forms into which these antique races have thrown the natural objects we have named constitute, by universal consent, the very grammar of ornament—a grammar which must be

mastered by every one who would address and captivate the eye. Such knowledge acts as a wholesomely restraining law on the otherwise exuberant fancy of the designer, and keeps him true to æsthetic propriety and historic association.

Some writers on applied art, however, would appear to hesitate as to how far conventional treatment should be adopted by the designer, and how far he should follow more immediately nature. To our thinking, there ought to be no hesitancy in the matter. If the reader will remember for a moment that all art is at best but a compromise, even in the most finished pictorial representation, he will have no difficulty in coming to the conclusion that that art which does not profess to be realistic, but is only suggestive, need not follow nature unless in one or other of those conventionalised forms which, we have already said, come to us with the sanction and authority of a stupendous past. Their full significance and symbolism may be lost to us, but their æsthetic beauty and value remain a possession with us for ever. They are the texts of art which may scarcely be multiplied, but which may be expanded, varied, and applied with all the infinity pertaining to the mind of man. Still, it is quite possible for one with a genius for selecting and re-arranging to combine the leading features of Egyptian, Greek, and Oriental decoration in one fine design, enlivening the whole with a touch of naturalism here and there; but, as has already been remarked, he must be a man of genius.

In textures, then, the design must always be conventionally treated, and with the least possible shadow. I could imagine a designer of taste introducing here and there, at rhythmic intervals, on wall hangings or paper the tiniest bit of realism in the shape of an insect, an animal, or a flower, somewhat in the manner of classical grotesques, only treated more rationally; but the practice in unskilled hands is exceedingly apt to degenerate into a vulgar realism, and is, therefore, on the whole, to be eschewed. All can remember the misapplied patience and ingenuity with which the carpet designer of thirty years ago made our hearth-rugs terrible to behold by converting them into the lairs of lions, tigers, and other wild beasts, outraging alike æsthetic sensibility and common sense.

But besides the figured design, whether geometrically treated, or bearing more on the organic forms of nature, or showing a harmonious blending of both, there is what may be called a *colour pattern;* and here the artist has a wide field for the display of his ingenuity and taste. There may be in such colour pattern no definite figure asserting itself anywhere, and yet the whole be to the eye a perfect garden of delight.

Without touching at all on the scientific theory of colour or the laws of optics, it may be permissible to make such remarks as must have occurred to every one ordinarily observant, and the truth of which cannot too often be insisted on. This must often have struck the reader; for instance, that, when two strong primary colours—to use an old-fashioned, but intelligible, terminology—are placed in juxtaposition, the eye is distressed. This arises, no doubt, from the overlapping rays of the two violent colours producing a third and unexpected colour, such third colour being a surprise, an intrusion, and an offence.

In the thirteenth century stained glass consisted mainly of red and blue, as in some of the windows of Canterbury Cathedral, producing an obnoxious purple; but as time went on, the colour-sense became more delicate, practice improved, and the artists of the following age made the obnoxious purple impossible by introducing between the primaries white, or low-toned tertiaries, so that before it could cross such boundaries the purple became not only inoffensive, but positively pleasing. The intervention of atmosphere often serves a similar purpose. A stained glass window on an easel in the studio looks hard and coarse; but in a cathedral apse, three hundred feet from the eye, the intervening atmosphere tones it into harmony. Again, the violent coloured shawls, but lately so familiar in our country lanes, which covered the plump shoulders of Betsy, the dairymaid, softened into sweetness as her figure and that of Dick, the ploughman, receded into the grey-green distance created by the road and the double line of the bramble and briar-scented hedge.

Tartans, especially those designed by the modern manufacturer, are exceedingly obnoxious to English taste; yet many of the old clan patterns, even those in which the most violent red predominates, are marvellously harmonious. Take, for example, the Robertson tartan, which is composed of one square of green, one square of blue, and two of brilliant red. One can easily imagine how combative such a combination would be; but every alternate square of red is toned down by a facing, so to speak, of blue in one part and of green in another, so that the whole pattern, when seen a few yards off, becomes one of the liveliest and most pleasing of purples, being modified, of

course, by the chromatic conditions of its surroundings. A lady seen on a snowy day so beplaided gives warmth and exhilaration to the whole landscape. Such examples we call *colour pattern*, and this checker or tartan variety of it is extremely ancient, and comes, as Pliny the elder, who wrote in the first century, informs us, from Gaul. Dion Cassius, the historian, who flourished in the latter half of the second century and well into the third, describes Boadicea as wearing under her mantle a checkered tunic of many colours; and so beautiful were the tints which the ancient Britons gave to their wools, says the Rev. Dr. Rock, that strangers wondered at, and some were jealous of, their splendour. The same scholarly authority thinks we are fairly warranted in regarding these colour-patterns of the ancient Gauls and Britons as something very similar to the plaid checkers of the Scottish Highlanders; and the northern Briton, therefore, may be pardoned the vanity of venturing to believe that the conquering legions of the antique world had the taste to admire, as they had frequently grim cause to respect and fear, the flutter of the tartan.

This sense of colour and its blendings, the Celts brought with them from the East, and its survival is still brilliantly potent among us; for, in spite of modern affectation and the outcry at their so-called crudeness, many of the clan tartans, when viewed under proper conditions, show a feeling for harmony and tone which the practice of long centuries has turned into a delicate and unerring instinct. The chromatic modulations produced by the Highland weaver with red or green for a key-note, and occasionally with white, if sometimes startling and defiant, are much more frequently soothing and altogether beautiful. It is curious to notice that the Celtic element among the French people asserts itself with almost periodic regularity by making every now and then Scottish tartan fashionable.

From all this we would gather that manufacturers, in dealing with bright colours, would do well to introduce between the primaries white or black, or, what would serve equally well, some low-toned colour, and this brings us to the consideration of tone itself, a thing hitherto not very well understood by our manufacturers, or, at all events, coming only lately under their sympathetic cognisance.

Now *tone*, above all things, ought to be pure, without any admixture of dirt. Not alone to blame are the makers of those dingy wall papers which are associated with the name of a distinguished living poet (whose own designs, we think, in most cases are unexceptionable), and which on that account, doubtless, have become fashionable; or of those so-called sage-green fabrics, so run upon for ladies' dresses; we could name Royal Academicians, who fancy they are giving us tone, when they are really giving us smudge. The difference between pure tone and smudged tone may be put practically in this way. Take a piece of hard, crude red or blue cloth, and rub it in the dirt of the garden, and when brought in, the "exquisitely æsthetic" in matters of colour would call this "toned" red, or "toned" blue, as the case may be; and such toning is what delights multitudes of people, who can scarcely be called "cultured" or "intense," but, who, sheep-like, follow with "baaing" admiration the examples set by those "directors of taste" who ought to know better. But for the toning which would please a healthy and really educated eye, we must hang in front of our crude red cloth a piece of thin Eastern muslin, or the finest grey crape of Japan. Then we have tone indeed, for it is pure. The first—the mud-stained cloth—we would call the fashionable paper-wall-red, but the second, the red of Japan.

So-called "sage green," which is happily now fast disappearing, is another example of dirty toning. The manufacturer's sage-green fabric, like the fashionable red of the paper-makers, is simply colour and dirt, and a libel on the lovely leaf whose name is so unwarrantably appropriated. Real sage green is simply green grass seen through a cloud of silver grey, and the manufacturer has not yet produced it. Of this he may be sure, that two rugs equally good in colour—however much they may differ in design and pattern-colour—when placed side by side, will go perfectly together. If they do not, then one of them is wrong. Any dominating neutral tint may be wonderfully sparkled up by the judicious introduction here and there of dots, or small patches, of bright positive colour.

Our manufacturers, moreover, do not appreciate at its full value how much may be gained by the use of various tints of the same colour, especially in raised work, whether in shawls or carpets. We have seen a piece of Indian embroidery in which the pattern was little or nothing but a series of daisies, and various leaves closely set; but perhaps fifty of them were in lemon gold, and seventy in orange gold—at all events, the two groupings were unequal in bulk, and distributed in no regular manner, only at each end of the shawl—for it was plaid-shaped, and the thick-set mass of daisies and leaves was thrown into elongated ovals, whose boundary line was a narrow ribbon of blue grey net

of the most exquisite texture. The body of the shawl was composed of the same diaphanous tissue with single yellow leaves of peculiar character strewn all over it. This produced in the eye such a sense of richness that you were under the impression that there were in the piece at least half a dozen different tones. With two or three shades of green, something similar could be done with carpets. What, for instance, might not be made of the hart's-tongue fern, could the carpet weaver but give it the effect of the feather-stitch! For many years manufacturers have been feeling their way in this direction, and we have no doubt the ingenuity and educated taste of the Whytocks of Edinburgh, the Templetons of Glasgow, and the Crossleys of Halifax—to all of whom carpet texture and designing owe so much—will yet lead to æsthetic triumphs greater and more permanent than any they have yet achieved. What is wanted, then, in colour, which is to be near the eye, is *atmosphere;* and when the manufacturer wishes to know whether there is unity in his pattern and harmony in his tints, let him look at his design through an inverted opera-glass, and that will help him amazingly.

Reverting to patterns of design, we would prefer those of a kind that could be looked at either up or down, and be beautiful from any side, especially in fabrics for women. A lady's dress consists of a body, sleeves, and skirt, and it is evident as she moves her arms, that the pattern, if it goes all in one direction, cannot always be seen as it ought to be seen. Now a pattern—whether on the wall, on the floor, or on a lady's back—which cannot be instantly grasped and enjoyed, is bothering to the eye; and it may be taken as a general and irrefutable axiom, that whatever bothers is not art. The chief function of art, in whatever branch, is to convey pleasure; and if a pattern, either in design or colour, irritates or puzzles the brain, it cannot, we repeat, be true art. The Persians and other Eastern nations show how thoroughly they understood this in the designing of their rugs and carpets. I do not say but what the angles of a rug or shawl may not be occasionally emphasised, or, that a wall-paper pattern may not sometimes meander upwards in a natural way conveying the idea of growth; but the full drift and nature of such emphasis must bespeak the eye kindly and "coothily." Many of the patterns on old Chinese porcelain —the hawthorn of the Nankin blue, for example—lend themselves most readily to the printer of cottons, and our manufacturers could scarcely do better than transfer them bodily to their fabrics. They can be looked at from any side, up or down. Of course, how far the pattern will fill the space to be occupied, or what relation it will bear to it, will depend entirely on the taste and judgment of the designer.

Generally speaking, he confines himself too exclusively to his books and his drawing-board, and trusts over-much to his inner consciousness. Now, a man may be consumedly clever at appropriating the ideas of others, or bringing forth from his mental store-house all manner of fresh combinations and quaint devices; but their term of currency rarely exceeds a single season. The richest imagination can scarcely hope to compete with the infinite variety and boundless wealth of Nature. For example, one of the most effective patterns for wall hangings which the Messrs. Warner and Ramm, the eminent furniture silk manufacturers—who, by the way, have succeeded in making brocades sixty-three inches in width, whereas formerly they were only twenty-one—have produced, was suggested to them by a sketch made by an observant friend, an architect by profession. On a visit to Chatsworth, he was very much struck by the Duke of Devonshire's cultivated variety of the common ox-eyed daisy, a field-flower, which his Grace has converted into a stately plant, six or seven feet in height. The architect made a drawing of it—flower, bud, and leaf—and when casually submitting it to his manufacturing friends, they saw what rare possibilities of design were in it, and ultimately produced therefrom a beautiful three-coloured silk damask.

The true designer, therefore, will seek Nature continually, and trust her implicitly. In the neighbouring aquarium he will watch the freedom of sweep and exquisite quality of curve peculiar to the form and motion of the various fishes, and these he will seize, in part or in whole, and cunningly utilise; for a single dot or line—an oaten straw, or a bamboo stem—becomes decorative when geometrically treated. Or, he may stroll through the fields and linger by the river side, noticing the wild flowers, the grasses, and the sedges, marking the grace of their waving, or the helpless droop of a broken stalk. Or, if colour-pattern be his object, let him roam the fields, the woods and wilds, or wander by the sea-shore. For ladies' silks, what more lovely than the delicately-graded tints of a pigeon's neck, or an ocean shell? What harmony in the wing of the owl, the pheasant, or, for that matter, of the common barn-door fowl! What marvellous suggestions will the designer with

eyes to see, behold in the plumage of the black-cock, the wing of the jay, or the head of the cassowary! The grey and black and red and white of the last-named might in five minutes be turned into a lovely pattern. From a volume of patterns kindly placed at my disposal by the firm already named, it is evident the French silk weavers of the seventeenth century had a very fair understanding of all this. The unique folio in question belonged to the Huguenot weavers settled at Canterbury, and is dated 1684, the year preceding that of the revocation of the Edict of Nantes. It is curious to note how these important immigrants advanced in their art after settling in their new homes, as if the free air of England had ripened their natural taste, and stimulated anew their genius for invention. This volume shows that they began weaving silks with printed warps, then came figured silks, which in turn gave way to the brocading of flowers on twills and satins. Next we find these flowers brocaded on silk gauzes, and this fabric was in its turn replaced by striped velvets with tissued figures, which were succeeded by velvet and "terry,"—terry being a loop of silk with the wire drawn out, whereas the velvet, as most of our readers are aware, is the loop of silk cut. Dots, lines, curves, sprigs, flowers, and the like, were changed, interchanged, and utilised in a hundred different ways, and the Huguenot, like the modern French designer, shows how frequently—in the true art spirit—he referred to nature.

To the true artist, indeed, everything in nature is his, whether in its parts, its entirety, or its multitudinous mass, from the feelers of a fly to the trunk of an elephant; from the fields "with daisies pied" to the "floor of heaven when thick inlaid with patines of bright gold;" from the white-flecked grey of the ocean-spindrift to the crimson and purple glories of the sinking sun. Once more, therefore, would we urge on all concerned to imitate the grand examples set by the Egyptians, and the Greeks, and the ancient nations of the farthest Orient, and go, like them, to the exhaustless treasure-house of Nature.

INDUSTRIAL LEGISLATION.—XII.

THE COMPROMISE OF 1850—UNJUST REFLECTIONS UPON LORD SHAFTESBURY—SATISFACTORY WORKING OF THE NEW ARRANGEMENT—EXTENSION OF THE FACTORY ACT TO BLEACH-WORKS IN 1861—THE INQUIRY OF 1862 INTO THE EMPLOYMENT OF CHILDREN AND YOUNG PERSONS IN TRADES NOT REGULATED BY LAW.

BY JAMES HENDERSON, ONE OF H.M. SUPERINTENDING INSPECTORS OF FACTORIES.

LORD SHAFTESBURY'S acceptance of the compromise set forth in the Factory Act of 1850 was the source of a good deal of dissatisfaction and heartburning. Several of those who had co-operated with him in the factory agitation, did not hesitate to denounce him as a traitor to the "cause." A candid examination of all the circumstances however, we think, establishes the injustice of any such charge, and proves that Lord Shaftesbury was fully justified in the course which he took. He assented to the compromise on the ground that twenty years of well-balanced conflict showed that neither party could gain its full purpose, and that a compromise was the only satisfactory solution of the difficulty. The gain to the work-people by the terms of that compromise was undoubtedly much greater than the concession to the employers. For the sake of the additional half-hour a day, the latter had surrendered their right, under the Act of 1844, to extend the hours of work over a period of fifteen hours, and had agreed to close their factories at a uniform hour. The value of this concession was recognised by many of the leaders of the operatives at the time, and eventually it may be said to have been accepted by all. Lord Shaftesbury's whole conduct throughout the agitation on behalf of the factory children may be referred to as a complete refutation of the charge so recklessly and thoughtlessly brought against him. In this cause he had sacrificed, it may be said, his political career, for he allowed nothing to interfere with his determination to prosecute it to a successful issue. He was opposed by a formidable array of capitalists, mill-owners, doctrinaires, and men who by natural impulse hated all humanity-mongers. They influenced the ignorant, the timid, and the indifferent, and Lord Shaftesbury's strength in the House of Commons was for many years among the Radicals, the Irishmen, and a few independent Whigs and Tories.

The Factory Act of 1850 practically closed the controversy which had been waged upon this question for more than half a century. A regular system of inspection was now organised, and for some years the action of the Legislature was limited to the passing of various minor measures, which remedied defects and omissions which were brought to light by those charged with the important duty of administering the law. The first of these was a short Act passed in 1853, which extended to children the same regulations which the Act of 1850 applied to women and young persons. It forbade their employment either before six in the morning or after six in the evening. For this very much needed amendment upon the Act of 1850, the factory operatives were indebted in a large degree to Lord Palmerston.

About this time, the textile manufacturing districts in the North of England were greatly exercised over the question of the fencing of machinery. Her Majesty's Inspectors of Factories issued a circular on the subject, which excited much alarm, as imposing needless and expensive restrictions upon the mill-owners. Indignation meetings were held in various parts of Lancashire and Yorkshire, and at one time a total suspension of the textile manufacturing industries carried on in these counties was threatened. This led to the passing of a short Act in 1856, in which the responsibility of the mill-occupiers in respect to the fencing of machinery was clearly and definitely stated.

The next important stage in the history of factory legislation was marked by the passing of an Act in the session of 1860, placing bleaching, dyeing, and finishing works under regulation and inspection. In very many cases these processes, or some of them, were carried on in connection with print works, and for several years much dissatisfaction had been felt because the women, young persons, and children employed in them were wholly unprotected, while the Act applied to workpeople engaged in the print work, possibly on the same premises. This extension of the Act was, however, resisted very stoutly by the employers, and it required a good deal of persevering agitation to induce the House of Commons to deal with the question. The chief centres of the bleaching and finishing trades were in Lancashire and the West of Scotland, and every candid and unprejudiced person who was acquainted with the customs of the trade was compelled to admit, that the application of some such regulations and restrictions as those imposed by the Factory Act was very much required indeed. Comparatively few children were employed in bleach-works, but there were large numbers of young girls and women, who were subjected to treatment which was most cruel and oppressive. Very long hours of work were indulged in, and in some of the works the women and girls were exposed to a very high temperature when working in the drying stoves. It was established in evidence that, occasionally, girls would be kept at work for two or three days and nights continuously; and as they had to keep on their feet the whole of the time, the exertion had a most mischievous influence on their health. In the West of Scotland it was not at all an uncommon thing to find strong and hearty girls completely invalided for life, after two or three years' work in a bleachfield. The constant exertion imposed upon them brought on swellings in the legs, varicose veins, and other disorders which wholly unfitted them for earning their living in any employment, and too frequently they were compelled, when still young, to find refuge in the workhouse.

In the West of Scotland, also, a very bad practice prevailed of lodging the women employed in a bleach-work in a sort of barrack, called the "woman-house." This was an extension of the infamous bothy system, which prevails in many of the agricultural counties in Scotland, and which undoubtedly exercises a most vicious influence on the morals of the Scottish peasantry. As may be very well understood, the example of one or two bad characters among a number of young and innocent girls, under such circumstances, was most pernicious, and the ruin of many could be directly traced to this cause. Although no direct attempt was made by the Factory Act to counteract this evil, yet its influence when extended to bleach-works was very beneficial. The limitation of the hours of work, and the establishment of regular meal-times, did away with the necessity of having the women lodged on the premises. They were free to reside with their friends and relatives, and very soon a large number availed themselves of this privilege. The "woman-house" has not yet altogether disappeared from the bleach-works in the West of Scotland, but it is allowed that the worst features of the system have been greatly modified.

Mr. Crook, the member for Bolton, took an active part in advocating the Bleach-works Act, and visited various parts of the country in order to enlist public sympathy on its behalf. He introduced

the Bill, by which it was proposed to place bleaching and dyeing works under inspection, into the House of Commons, and had no great difficulty in getting it passed. A feature of some novelty was introduced into this measure. The muslin bleachers and dyers, with a fair show of reason, urged that their trade was one subject to frequent fluctuations —that as they finished the goods, and made them ready for the market, they were frequently called upon to complete a shipping order within a limited time; and that much inconvenience would be imposed both upon them, and upon all interested in the manufactures of the country, if some allowance was not made to them which would enable them to meet emergencies of this kind. A clause was inserted in the new Act, enabling bleachers and dyers to make up lost time by working up to eight o'clock in the evening during the week, and till half-past four on Saturdays. This principle of making some allowance for the unpreventible fluctuations of trade, was more fully recognised and amplified under the Factory Acts Extension Act of 1867, as we shall find when we come to examine that measure in detail.

About this period (1861) public attention was drawn to the very partial and unequal application of the restrictions imposed upon the employment of women, young persons, and children. It will be remembered that it was a common objection taken to Lord Ashley's agitation in favour of the Ten Hours Bill in the textile manufactures, that there were other industries which it was equally necessary and desirable to regulate. Lord Ashley's reply to criticisms of this kind was the very simple one that it was best to attend to one thing at a time. That he did not overlook the sufferings of children and women employed in other occupations than those carried on in textile factories, was evidenced by the earnestness he evinced in getting measures through the House of Commons for regulating the employment of climbing boys in chimney-sweeping, and forbidding that of girls and women in underground mines. But outside of these there was a mass of occupations in which many abuses existed, and the mischievous evils which were known to follow had been partially exposed in the report of the Royal Commission which inquired into the subject in 1840.

It was therefore now thought a convenient time to revive this question, and accordingly a fresh commission was appointed to inquire into, and report upon, the employment of children and young persons in trades and manufactures not already regulated by law. On entering upon this important inquiry, three classes of manufactures presented themselves for consideration: first, those in which a disposition had been manifested either by employers or work-people engaged in them, or by both, in favour of their regulation by Act of Parliament; secondly, those which had grown into importance since the inquiry of 1840–2, some of which came within the category of "noxious trades," and were well known to cause serious injury to the health of the persons employed in them; thirdly, those in which the Children's Employment Commissioners of 1840 had shown by their reports, and by the evidence which they collected, that the greatest need existed for the extension of legislative protection, but which had not yet been dealt with. Among the occupations thus included, and upon which the Royal Commissioners were enabled to give an opinion in their first report, were the pottery manufacture, the lucifer match manufacture, the percussion cap manufacture, paper-staining, the employment of finishing and hooking, fustian-cutting, the lace manufacture, and the hosiery manufacture. The most important industry on this list so far as numbers went was the pottery manufacture, which is mainly concentrated in North Staffordshire. A large body of the employers in that district had invited an inquiry, and Mr. Longe, one of the assistant Commissioners, made a most elaborate and interesting report upon the physical and moral condition of the work-people. The medical evidence collected strongly confirmed the conclusion that this was a trade which ought to be placed under regulation. Dr. J. J. Arlidge, the senior physician of the North Staffordshire Infirmary, gave the following description of the work-people of the district:—"The potters as a class, both men and women, but more especially the former, represent a degenerated population, both physically and morally. They are as a rule stunted in growth, ill-shaped, and frequently ill-formed in the chest; they become prematurely old, and are certainly short-lived; they are phlegmatic and bloodless, and exhibit their debility of constitution by obstinate attacks of dyspepsia and disorders of the liver and kidneys, and by rheumatism. But of all diseases they are specially prone to chest disease, to pneumonia, phthisis, bronchitis, and asthma. One form would appear to be peculiar to them, and is known as potter's asthma, or potter's consumption. Scrofula, attacking the glands or bones or other parts of the body, is a disease of two-thirds or

more of the potters. The men are more subject to chest disease than the women; the latter employed in 'dipping' or in 'printing' suffer most, those engaged in painting, burnishing, and in the ware-rooms least. The most sickly men are the hollow ware pressers, firemen, and dippers."

In Dr. Arlidge's opinion the condition of the population in the pottery districts would have been very much worse than is here described, but that it was constantly recruited from the surrounding country districts, and by intermarriages with more healthy men.

The children were employed in the potteries at a very early age, and the practice was denounced by Mr. Benjamin Boothroyd, surgeon, then Mayor of Hanley, as one "of the most deleterious and destructive of human life in the country," and that it was rendered so "by the faulty construction, imperfect ventilation, and over-crowding in the workshops." It was estimated that over eleven thousand children and young persons were employed in the manufacture of pottery ware under the conditions we have described, and the Royal Commissioners, after giving a careful consideration to the whole circumstances of the trade, did not hesitate to recommend that they should be placed under the protection of an Act of Parliament. This conclusion was readily concurred in by a large number of the employers themselves.

The second occupation reported upon was that of lucifer match-making. The number of persons employed in this trade was not large, being estimated at less than 3,000 in the United Kingdom. Two-thirds of these, however, were children and young persons, and the work they were engaged upon was particularly unwholesome. A most painful and loathsome disease, known as "necrosis of the jaw," or the "phosphorus disease," not unfrequently developed itself among those engaged in this manufacture. The sufferings of a patient in the earlier stages of this disease, and until it had run itself out and left the jaw quite dead and exposed, we are told, were intolerable. It is said that any amount of narcotics, almost, could be taken without appreciable effect being produced. The manufacture of lucifer matches was carried on chiefly in the centre of the largest towns, in the eastern and southern districts of London, and in Manchester, Birmingham, Liverpool, Glasgow, Bristol, Norwich, and Newcastle. The work-people employed, as a rule, were drawn from the poorest class of the population, whose uncleanly habits greatly aggravated the mischievous evils caused by the occupation itself.

Mr. White, the assistant Commissioner, who prosecuted the inquiry into this trade, had no difficulty whatever in establishing a strong case for legislative regulation. Among the suggestions which he offered as being likely to promote the health of the work-people were the following:—The complete separation of those rooms in which the phosphoric fumes are given off, from the rest, and from each other; ample and judicious ventilation; provision for cleanliness, and strict regulations against meals being cooked or eaten on any part of the premises where phosphorus was used. The evidence of the noxious character of this manufacture was so conclusive, that the Commissioners had no hesitation in recommending the application of most stringent regulations in regard to the arrangements of the several work-rooms. They insisted especially upon the isolation of those processes which were proved to be so deleterious to health.

The percussion-cap manufacture, paper-staining, and fustian-cutting were also reported upon strongly by the Commission, as requiring to be placed under legislative regulation.

SHIP BUILDING.—XXVII.

MODERN WAR-SHIPS: GUNS AND ARMOUR.

In the earlier stages of the contest between guns and armour, the latter, undoubtedly, had the advantage. The heaviest gun mounted on shipboard up to 1860 was the 68-pounder, weighing less than 5 tons; and this gun failed to pierce the target representing the armoured side of the *Warrior* at a range of 200 yards. The 68-pounder was a cast-iron smooth-bore gun, and was first introduced in 1840, when it was considered a great advance in the production of heavy ordnance. How greatly the rate of progress has been quickened by the rivalry of recent years will be evident from

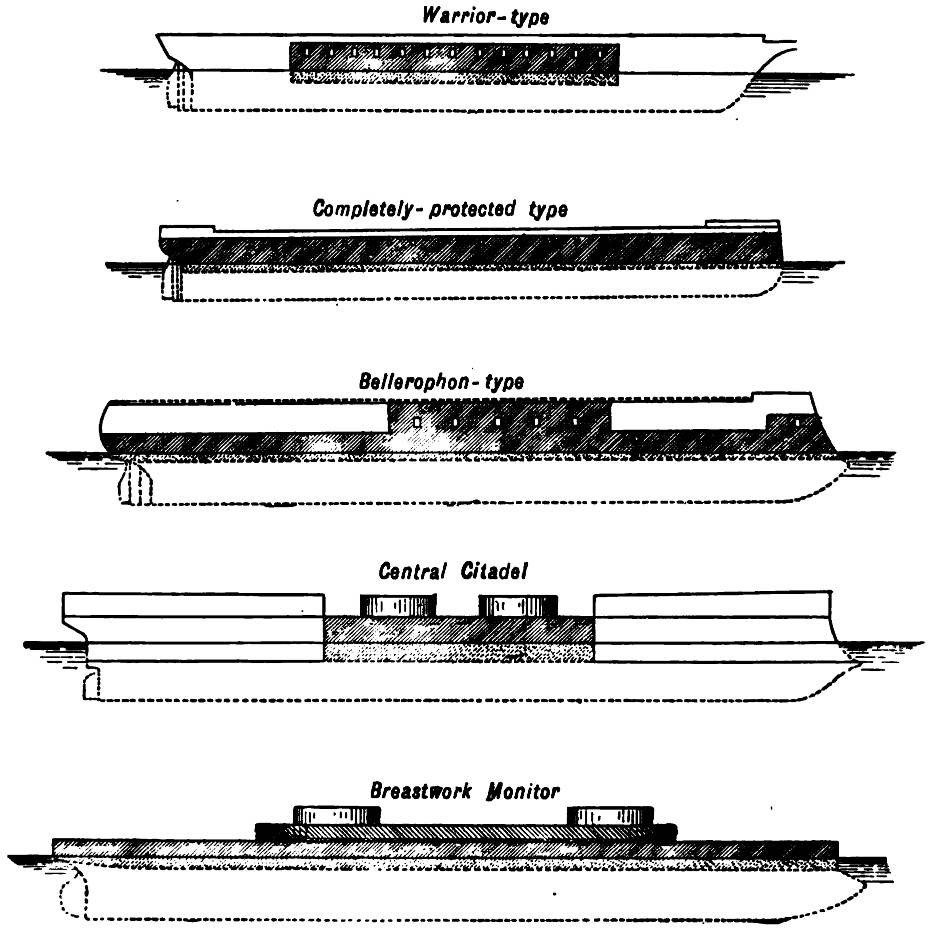
the fact that in 1876 a gun was made in England for the Italian Government weighing 100 tons, throwing a projectile weighing nearly a ton, and capable of piercing more than 2 feet thickness of solid iron at 1,000 yards' range. Sixteen years sufficed to increase the weight of the gun twenty-fold, and that of the projectile thirty-fold; while the armoured sides of the *Warrior* and *La Gloire*, which proved more than a match for the 68-pounder, are of no avail against the modern gun. On the other hand, naval architects have been labouring to increase the defensive powers of ships; and with so much success, that in the most recent examples they can oppose armour having a maximum thickness of 24 inches to the most powerful guns. Did limits of space permit, it would be interesting to trace this progress in the powers of offence and defence, and to show how each advance made in the power of guns has been met, or attempted to be met, by the use of stronger armour. We must be content, however, with a very brief sketch of what has been done.

Taking the armour first, we find that up to the year 1863 no vessel was laid down having a stronger target-side than that of the *Warrior*. In that year the *Bellerophon* was commenced, to carry armour 6 inches thick. Two years later the *Hercules* was laid down to carry 8-inch and 9-inch armour. In 1869 the *Devastation* and *Thunderer* were begun, the greatest thickness of iron on their sides being 12 inches, and on the turrets 14 inches. Four years later a step in advance was taken which equalled all the previous progress made during fourteen years. The *Inflexible*, designed in 1873, has a maximum thickness of no less than 24 inches of iron on her sides. This thickness has not yet been exceeded on any English ironclad, although the Italians are said to have vessels in progress on which armour 27 to 30 inches thick will be carried.

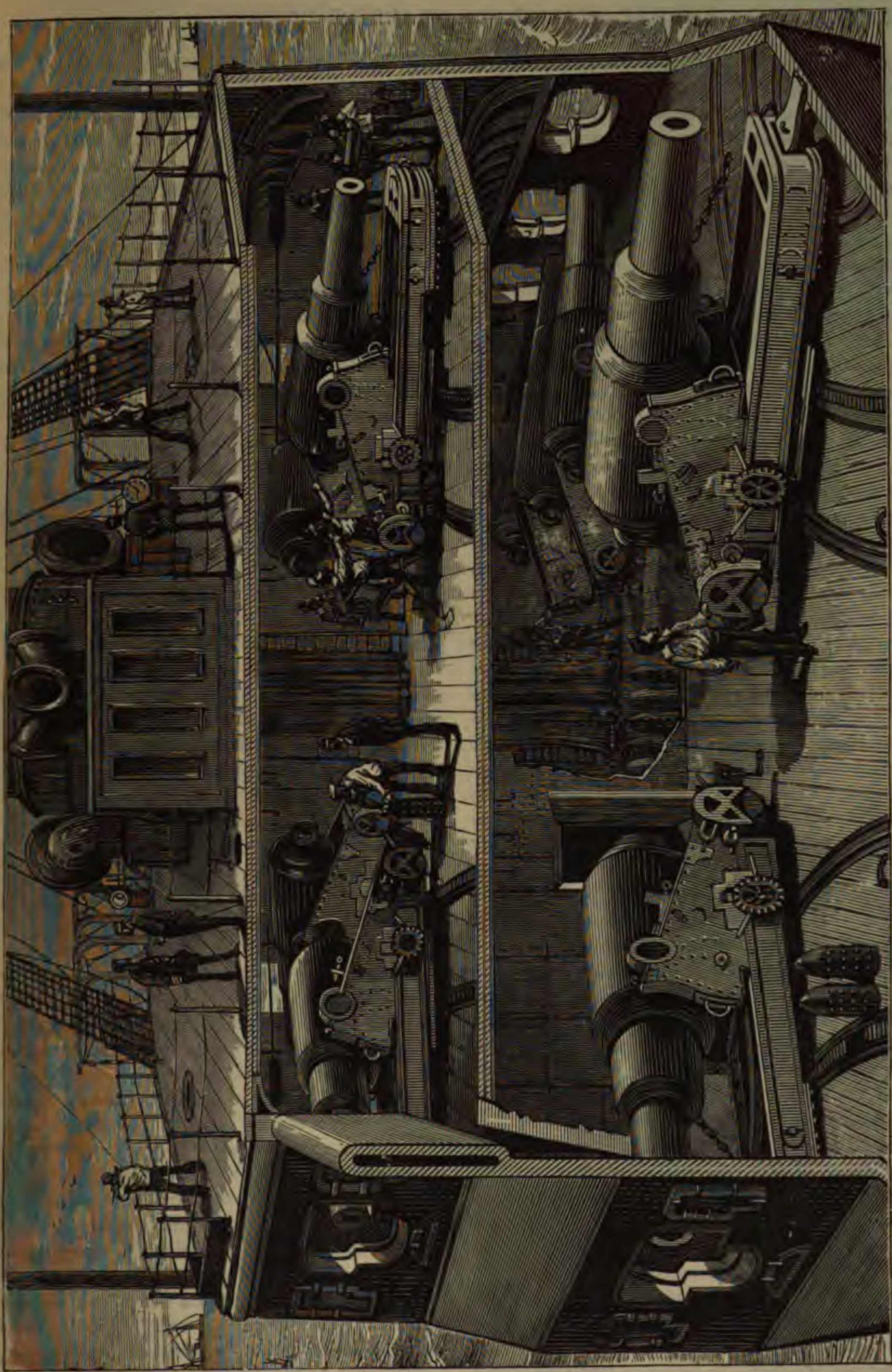
There is no reason to suppose that the manufacturers cannot produce still greater thicknesses of armour, if it should be considered desirable to use them. Armour-plate making in England has for many years past been a practical monopoly in the hands of the two great Sheffield firms of Sir John Brown and Co. and Charles Cammell and Co., who have made the plates for most of our own ironclads, and for a very large proportion of foreign ironclads. Up to the present time, it may be fairly said, that the manufacturers have been in advance of the demand: their appliances being capable of producing thicker plates than the ship-builder has required. When the earlier iron-clads were built, many of the armour-plates were "hammered," now the plates are invariably "rolled." A plate 4 tons in weight was considered a masterpiece in 1859; in 1879 plates 40 and 50 tons in weight could be produced. The limits of weight and size are fixed simply by the plant available for heating, rolling, and lifting these great masses: not by any difficulties incidental to the processes of manufacture.

For twenty years wrought iron stood unchallenged as the material best adapted for armour-plating. Its reputation was established after repeated trials made in competition with other materials; but since 1875 the progress made with the manufacture of steel is bringing that material into formidable rivalry with wrought iron. The Italians are using steel armour on their two large ships of the *Inflexible* type; and in the Paris Exhibition of 1878 a model was shown by M. Schneider of a steel ingot, suitable for making an armour-plate weighing 120 tons. During the last two years many experiments have been made in England with steel armour and with armour-plates, of which the face is steel and the back iron —the so-called "steel-faced" armour. In the *Inflexible* this steel-faced armour is being fitted on the turrets; and the makers claim for it an advantage over an equal thickness of iron of from 25 to 30 per cent. The chief reason for preferring such armour to steel armour is the greater freedom from cracking when struck by heavy projectiles. It has been found that steel unbacked by iron can be cracked and seriously damaged by the fire of guns not nearly powerful enough to penetrate the steel plates. On the other hand, with good wrought iron armour, cracking does not take place, and the damage done to a plate by the blow of a shot is very much localised, the other parts of the plate being little affected. By combining iron with steel the hard metal serves to break up the projectiles which strike it, while the iron back welded to the steel diminishes the amount of cracking. Sir Joseph Whitworth has worked out quite another plan, using comparatively small and thin steel plates of excessive hardness, and screwing them to a backing plate of softer steel. Some of the results obtained with targets of this character are most surprising. In fact, it is clear that with a given total weight of armour available, much stronger defence will in future be obtained than has hitherto been possible with wrought-iron armour.

Taking another mode of estimation than that of mere thickness of armour, the progress made in protecting ships of war appears no less remarkable. In the *Warrior* about 10 per cent. of the total weight of the ship is put into armour, in the *Bellerophon* about 14 per cent., in the *Hercules* 16 per cent., in the *Devastation* more than 25 per cent., and in the *Inflexible* probably nearly 30 per cent. We shall hereafter endeavour to explain how these results have been achieved. Turning to the means of offence, one finds at least equivalent progress made in the construction of naval guns. In 1860 the 68-pounder, a muzzle-loading smooth-bore gun, was first replaced to some extent by breech-loading rifled guns, designed by Sir William Armstrong, throwing 110-lb. shot. These, in their turn, gave place to muzzle-loading rifled guns, of which the heaviest, up to 1865, weighed 12 tons, and threw 250-lb. shot. This was followed by 18-ton guns, throwing 400-lb. projectiles, and by 25-ton guns, throwing 600-lb. shot. In 1871 the famous "Woolwich Infant" was completed, weighing 35 tons, and throwing 700-lb. shot; to be surpassed, two years later, by the 38-ton 800-pounder, one of which exploded on board the *Thunderer*. Then followed a great stride in advance, for in 1873 the construction of a 75-ton gun was proposed, and in 1875 the first 80-ton gun was actually completed and tried at the butts. Almost simultaneously the firm of Sir W. Armstrong and Co. were making 100-ton guns, some of which have since been purchased by the British Government. This is the limit of size and weight at present, but there is no reason to suppose that further progress is impossible, or even difficult. It has been stated on the highest authority that "guns have already been designed, and could readily be made in the the Royal Gun Factory (Woolwich), which would



DISPOSITIONS OF ARMOUR.



SECTIONAL VIEW OF BATTERIES IN THE IRONCLAD FRIGATE "ALEXANDRA."

surpass the 100-ton Armstrong guns in power to as great an extent as they themselves surpass the 38-ton gun." Other considerations than those related to manufacturing operations will, therefore, decide what the guns of the future are to be. And one feature which is not likely to be forgotten is the cost—for each of our 80-ton guns costs about £10,000, and each 100-ton gun costs about £16,000.

Estimating this progress in another fashion, namely, by the power of the guns to pierce solid iron armour, unbacked by wood, when chilled cast-iron projectiles are used, we find equally remarkable results. The 68-pounder failed to pierce 5 inches of iron; the 6½-ton gun is about capable of piercing 7 inches at a distance of 1,000 yards, supposing the hit to be direct. The 9-ton gun can perforate about 8 inches, the 12-ton gun about 9½ inches, the 18-ton gun about 12½ inches, and the 38-ton gun about 18 inches at the distance of 1,000 yards; while the powers of the 80-ton and 100-ton guns are not yet thoroughly determined, but may be supposed to lie between the perforation of 2½ to 3 feet of iron at 1,000 yards. The armour of no ship afloat could resist the fire of these monster guns at close range if the projectiles struck normally; but in action most of the blows are struck obliquely, and this is a great advantage to the resisting power of the armour. In the fight between H.M.'s ship *Shah* and the Peruvian ironclad ram, *Huascar*, this fact received forcible illustration, for the latter, without sustaining serious damage, received several hits from the heavy projectiles of the *Shah's* rifled guns at ranges where they should have completely perforated the armour. It is necessary to have regard to this consideration in estimating the powers of offence and defence of armoured ships: for target experiments, such as are constantly being made at Shoeburyness, are unduly favourable to the guns.

Costly experiments and elaborate scientific investigations have been necessary to this advance in the power of British artillery. The structure and dimensions of the guns, the weight and character of the powder-charge, and the form and manufacture of the projectiles have all received careful study. It would be foreign to our purpose to enter into any description of these investigations; but there are two matters which cannot be left unnoticed. First, the mechanical arrangements for working and loading these heavy guns when mounted on board ship. Secondly, the new departure made quite recently in the forms and proportions of guns. So lately as 1863, when the *Bellerophon* was designed for 12-ton guns, it was questioned by eminent ship-builders and engineers whether guns of such a weight could be worked upon the broadside. Up to that time manual power had been trusted to train the guns, run them in and out, elevate and depress, &c. The gun-carriages also resembled closely those in use a century earlier. All fears of failure were soon dispelled. Simple and efficient mechanical appliances were devised, which enabled comparatively few men to handle and control the 12-ton guns. Success in this first trial led to further improvements and the devising of apparatus which enables guns of 18 and 25 tons' weight to be fought on the broadside. The heaviest guns are, however, mounted either in turrets or on turn-tables, by the revolution of which the guns are trained, while the other movements of the guns are performed by hydraulic or steam power. Hydraulic apparatus is now used for loading the guns as well as for working them, and thus even a 100-ton gun can be fought by a crew not much exceeding in number that formerly required for a 68-pounder. It is obviously of the greatest consequence that the number of men exposed in action should be minimised; and, apart from this consideration, manual power alone would be almost helpless in loading and working one of these monster guns, of which each of the shots weighs about *a ton*, while the powder-charge exceeds *one-fifth of a ton*. But with our present appliances, suitably modified, guns of any weight that can be made can be easily worked by a few men, and in this direction also there is no bar to progress in the use of heavier guns than have yet been produced.

At the same time there is reason to believe that the researches made of late years into the action of explosives, and the conditions most favourable to the efficient combustion of gunpowder, will enable guns of less weight to equal in power, if not surpass, the heaviest guns now in use. The principal change recently made in guns has been an increase in the length of the bore in proportion to the calibre, and an enlargement (or "chambering") of the space in which the cartridge is placed. Improvements of a very notable character have also been made in the powder and cartridges, with a view to render the combustion of the charge slower and more efficient. The results have been very satisfactory. Not long ago a 6-inch gun weighing less than 4 tons, manufactured by Sir W. Armstrong, was tried at Shoeburyness, and proved nearly equal to the 12-ton gun used in the Royal

Navy. It is thought that an 8-inch gun weighing less than 12 tons, built on similar principles, would prove more powerful than the 25-ton guns now in use; and that a 40- or 50-ton gun would be nearly equal to the present 80-ton gun. In these lighter but longer guns the powder-charge is very heavy, and the velocity of the projectiles is extremely high. The 6-inch Armstrong gun, for example, had a charge of 33 to 36 pounds of powder, which is about equal to the charge usually given to 9-ton Woolwich guns. Such an increase in the ratio of the power of guns to their weight cannot fail to be influential on the construction of further armoured ships; and it is likely to lead to a revision of the armaments of existing ships. In this new departure we have, in fact, a gun weighing less than the 68-pounder of 1860, but capable of piercing twice or thrice the thickness of armour which the earlier gun could penetrate. One consequence of the adoption of the new type will doubtless be a return to breech-loading. The earlier Armstrong rifled guns were breech-loaders, but since 1862 muzzle-loading has been preferred for British guns, although French and German artillerists have retained breech-loaders. The controversy between the two systems of loading has been long continued, but it now seems approaching a settlement, improved methods of closing the breech having been brought into use.

One result of the increase in the weight of naval guns has been a diminution in the number carried by an individual ship. The line-of-battle ship of 1855–60 carried, on three tiers, about 121 to 131 guns. Take the *Howe*, for example, a magnificent three-decker which has never been at sea. She was intended to carry 64 guns of 65 cwt. each, 34 of 56 cwt. each, 22 of 42 cwt. each, and 1 68-pounder of 95 cwt., in all 121 guns. Contrast this with the armoured battle-ship *Inflexible*, carrying only 4 guns, each weighing 80 tons. It will be seen that the total weight of the guns on the two ships is not very different; but the total weight of guns, powder, and projectiles on the ironclad would be largely in excess of that on the three-decker. The weight of metal thrown from each broadside of the three-decker was only 2,500 pounds, 60 guns delivering fire simultaneously; the corresponding weight for the 4 turret-guns in the *Inflexible* is about 7,000 pounds. In range and accuracy of fire the heavy rifled guns are, of course, beyond comparison superior to their predecessors; but, on the other hand, their fewness is a disadvantage, for in naval actions, even with trained gunners, the ratio of successful hits to the total number of shots fired can hardly ever at any time fail to be very small. Admiral Hamilton drew attention to this subject in 1878, and gave some striking examples of the fact that out of many attempts few successful shots are usually made in naval actions. Out of 1,000 shot and shell fired at the Federal ironclad *Essex*, by the Confederate batteries at Port Hudson, twenty-three only struck her hull. In the action between the *Kearsarge* and *Alabama*, the former fired 173 rounds before she sank the latter, and was herself hit only twenty-eight times during the hour and a quarter that the fight lasted. In trials made with English ships firing against rocks or fixed objects while the ships were in motion, very similar results have been obtained. There has, of late, been a disposition to favour what are termed "mixed armaments," in order to give ships a greater number of chances of hitting. Instead of carrying only two or four very heavy guns, a considerable number of lighter guns are also carried, unprotected by armour. This was a feature in all the designs for French armoured ships exhibited in Paris in 1878, and it is being extensively adopted in other navies.

The preceding remarks on naval guns will help the reader better to understand the reasons for the various *dispositions* of armour, which have been adopted in different classes of ships. From 1855 up to 1875, all authorities agreed in using *wrought iron* armour plates, as the best protective material available, but there was no similar agreement as to the best mode of arranging the armour. A few of the principal arrangements which have been used in English ships, are illustrated on p. 200. At the head stands the "*Warrior* type," with vertical armour limited to the central part of the ship, and unarmoured ends. Next is the "completely-protected" type of which the floating batteries were the first examples, while *La Gloire* in the French Navy, and our converted ironclads of the *Prince Consort* class, are more recent illustrations. Here the whole length of the broadside, from the upper deck down to a few feet under water, is covered with armour plating. Third there is the *Bellerophon*, or "belt-and-battery" type. The region of the water-line, from a few feet above water to a few feet below water, is protected by an armour-belt, which also protects the rudder and steering gear. Amidships there is a "box-battery" standing above the armour-belt, the sides and ends of this battery being covered with armour. In some examples this

central battery is in two storeys, with guns on each tier. In other cases, detached armoured bow and stern batteries are associated with a central battery. This is the system of protection most largely used in the period 1865—75, in English and foreign navies; and it will be easily seen that as the guns became fewer and the batteries smaller, so the area to be armoured was reduced, and the thickness of armour with a given weight, could be increased. Closely related to the belt-and-battery type is the "breastwork monitor" (p. 200). Instead of a broadside battery, an armoured breastwork is built above the water-line belt, and at the ends of this breastwork two revolving armour-plated turrets are placed, each turret containing two guns. Lastly we have the "central-citadel" type, of which the *Inflexible* is an example. The name explains the main feature in this class, but it will be observed that before and abaft the central citadel, instead of having a water-line belt of armour, there is a strong under-water armoured deck (shown by the continuous lines in the diagram). The unarmoured ends of the ship above this deck are easily penetrable by projectiles, but they are specially constructed and partially filled with cork-packing, so that it is expected that in action, they would be very slowly destructible. It is on the value of these unarmoured ends that a controversy arose in 1877; and all readers desirous of fully understanding the system of construction in detail will find the facts set forth in the report of the committee appointed by the Admiralty to investigate the subject. Suffice it to say that all the most recent first-class ironclads of the British Navy are armoured on this system, which has also been adopted in Italy and in Germany.

It will be observed that for a long period, the tendency has been to restrict more and more the area protected by vertical armour; and this restriction has given additional importance to horizontal or deck armour. In the ironclads built prior to 1863, little if any importance was attached to deck armour. Since 1865, however, there has been a great change. In the *Hercules*, for example, there were only 100 tons of deck-armour against 1,340 tons of vertical armour. Whereas in the *Ajax*, of 1875, there are no less than 700 tons of deck armour, and about 1,500 tons of vertical armour. In their latest armoured ships, the Italians have gone still further. They have abandoned the "central-citadel type," and protected their ships by an under-water armour deck, extending from stem to stern. Under the shelter of this deck the machinery, magazines, &c., are placed; and from the deck armoured trunks are built, reaching to the armoured towers containing the guns. The guns themselves are said to be fought *en barbette*, the armoured towers simply protecting the turn-tables upon which the guns are mounted, and the mechanical appliances for working the guns. Opinions are divided on the merits of this bold departure from previous practice, but it is generally conceded that as guns increase in weight, so the necessity for protecting them by armoured batteries or turrets becomes less. Very heavy guns are not likely to be seriously injured, even if they are struck by projectiles, and their chances of being hit are very small. We have only one ship, the *Temeraire*, with guns mounted in barbette towers, and on that vessel the guns disappear below the armoured walls when loading. The French and Germans, as well as the Italians, have made much more extensive use of the system; and its advantages in minimising the area of the surfaces to be protected by armour, are too obvious to need explanation.

One famous class of armoured ships of which no representation is given on p. 200, is the "monitor class" designed by Captain Ericsson during the Civil War in America. These vessels were constructed for service on the coasts and rivers of the United States, and more especially for the attack of Confederate forts. Externally they resembled rafts rather than ships. Their upper decks when fully laden were only one or two feet above water. Strong protective plating covered these decks, and the sides, throughout the whole length, were covered with vertical armour to a depth of three or four feet under water. Their armament was carried in revolving turrets, the bases of which were raised a little above the upper deck, so that the turrets could revolve freely. No vessels of this class have been built for the British Navy; but Russia, Sweden, and Norway have copied the American models, in vessels designed for coast defence. Our breastwork monitors are presumed to be improvements upon the American type, as regards their sea-going qualities and especially in being less liable to rapid foundering. In not a few instances during the Civil War these low freeboard monitors, after being damaged, sank in a very few minutes, with serious loss of life. It need only be added that artificial light and ventilation are essential conditions to the employment of the monitor types, both in our own Navy and in the American fleet. The change must indeed be great for seamen bred up in the high-sided line-of-battle ships of days gone by, where the accommodation was ample and natural ventilation sufficed, to

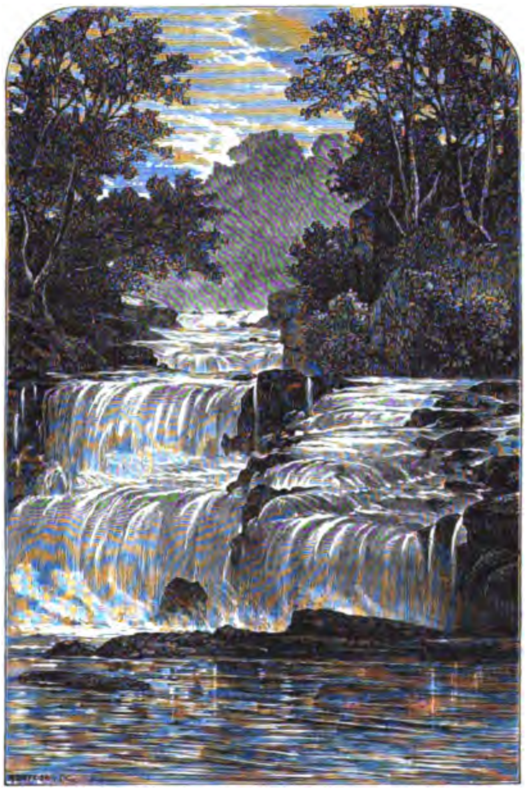
have to serve on board the monitors. But considerations such as these necessarily yield to those of increased fighting efficiency; and the magnificent, roomy, and comfortable three-decker is no match for the ugly monitor, whose crew live under water, and are saved from suffocation, when the vessel is battened down at sea, only by the continuous action of the ventilating fans driven by steam-power.

COTTON.—XXVII.

RISE AND PROGRESS OF THE COTTON MANUFACTURE IN SCOTLAND—TRADE OUTRAGES—MUSLIN-SEWING.

By David Bremner, Author of "The Industries of Scotland."

COTTON was spun and woven by hand in Scotland for a considerable time before Arkwright brought his machines into notice, but not to any great extent, as the people preferred to utilise their home-grown flax and wool. In the year 1778, a company of Englishmen built a cotton mill at Rothesay, in the island of Bute, and that was the first establishment of the kind in the country. At that time a Paisley weaver named David Dale, who had by severe toil at the loom accumulated a little money, was casting about for some enterprise in which he might embark his capital and his energies. The Rothesay cotton mill—a very small concern, by the way—took his fancy, and in the course of a little time he became lessee or proprietor of it. In his hands it prospered exceedingly well, and his success induced others to engage in the trade. Soon there sprang up on the banks of the streams of Lanarkshire and Renfrewshire a number of similar works, for the most part on a more extensive scale. Nine years after the Rothesay mill was opened, there were nineteen cotton mills in Scotland, all driven by water-power. Of these, four were situated in the county of Lanark, four in Renfrewshire, three in Perthshire, two in Midlothian, and the remainder distributed singly in different other counties. In view of the gigantic dimensions of many modern cotton mills, it may be interesting to state here that the second mill erected in Scotland—it was on the bank of the Leven, in Renfrewshire—was a modest structure of three storeys, measuring 54 feet in length and 24 feet in width, and the distance from the floors to the ceiling was eight feet.



Falls of Clyde: Corra Linn.

Respecting the early days of the cotton manufacture in Scotland, and the change in the fashion of dress which it gave rise to, Macpherson, in his "Annals of Commerce," says:—"The manufacture of calicoes, which was begun in Lanarkshire in the year 1772, was now pretty generally established in several parts of England and Scotland. The manufacture of muslins was begun in England in the year 1781, and was rapidly increased. In the year 1783 there were above a thousand looms set up in Glasgow for the most beneficial article, in which the skill and labour of the mechanic raised the raw material to twenty times the value it was when imported. Bengal, which for some thousands of years stood unequalled in the fabric of muslins, figured calicoes, and other fine cotton goods, is rivalled in several parts of Great Britain. . . . A handsome cotton gown was not attainable by women in

humble circumstances, and thence the cottons were mixed with linen yarns to reduce their price. But now cotton yarn is cheaper than linen yarn, and cotton goods are very much used in place of cambrics, lawns, and other expensive fabrics of flax; and they have almost totally superseded the silks. Women of all ranks, from the highest to the lowest, are clothed in British manufactures of cotton, from the muslin cap on the crown of the head to cotton stockings under the sole of the foot. The ingenuity of the calico-printers has kept pace with the ingenuity of the weavers and others concerned in the preceding stages of the manufacture, and produced patterns of printed goods which, for elegance of drawing, far exceed anything that ever was imported; and for durability of colour, generally stand the washing so well as to appear fresh and new every time they are washed, and give an air of neatness and cleanliness to the wearer beyond the elegance of silk in the first freshness of its transitory lustre. But even the most elegant prints are excelled by the superior beauty and virgin purity of the muslins, the growth and manufacture of the British dominions. With gentlemen, cotton stuffs for waistcoats have almost superseded woollen cloths, and silk stuffs, I believe, entirely; and they have the advantage, like the ladies' gowns, of having a new and fresh appearance every time they are washed."

Mr. David Dale was so successful in business that in 1784 Richard Arkwright sought to enter into partnership with him, but it does not appear that the matter was ever arranged, and Mr. Dale proceeded to embark single-handed upon a grand industrial experiment which he had conceived. This was the erection of a mill near the Falls of Clyde, and the foundation in connection therewith of a new community. The site selected was a lonely one, but a splendid supply of water was available for driving the machinery, and that consideration in those days was all-important. Simultaneously with the erection of the mill the building of cottages for the accommodation of the work-people was carried on. The machinery was started in 1786. It was expected that all the hands required for the unskilled work would be readily obtained in the neighbourhood; but the small farmers and cotters had had their minds so prejudiced against factory work that they showed no disposition to let the members of their families engage in it. To be shut up for twelve hours a day among machinery and dust, seemed a most uninviting thing to people who spent most of their lives in the open air, and were free to work or not, as they felt inclined. Finding that he could not obtain sufficient labour on the spot, Mr. Dale communicated with the managers of various charitable institutions in Edinburgh and Glasgow, and offered to maintain and educate any children who might be sent to him and permitted to work in the mill. His proposals were favourably entertained, and in the course of a little time about three hundred orphans of both sexes, and varying from seven to ten years of age, were committed to his care. In 1788 a second mill was built, and subsequently two others. Each of the mills was 160 feet in length by forty feet in width, and seven storeys in height. The hours of labour were from six in the morning till seven in the evening, with half an hour allowed for breakfast and dinner respectively. The Saturday half-holiday was then unknown. In course of time, Mr. Dale, who paid close attention to the health and comfort of his work-people, observed that the long hours were seriously prejudicing the health of the children, and he resolved to make a change in the working arrangements of his now extensive establishment. By adopting a system of relays, he provided that the children should work only three-fourths of the time exacted from adults. This admitted of the children being educated at a more seasonable hour than formerly. At the outset, night-schools had been provided, but the poor jaded creatures, on leaving the mill at seven o'clock, were but little disposed to apply themselves to lessons, and their education under such a system was necessarily a failure. Gratifying results of the change soon manifested themselves, and, thus encouraged, Mr. Dale remitted three hours of Saturday's labour all round. This concession was so highly appreciated that the work-people applied themselves more vigorously to work, with the result of producing a larger quantity of yarn during the limited number of hours than they did before. Not only did Mr. Dale reform his own establishment in the direction indicated, but he induced manufacturers in other parts to follow his example with results which proved beneficial to all concerned. Mr. Robert Owen, son-in-law of Mr. Dale, purchased the mills and cottages in 1799, and under his superintendence other reforms were carried out. The education imparted to the young people was of a thoroughly practical kind. In addition to a knowledge of the "three R's," the boys were instructed in gardening and agriculture, while the girls attended by rotation in the public kitchen to receive lessons in domestic economy. In the year

1820, New Lanark had a population of 2,400, of whom 1,700 were employed in the mills. From an account of the place written about that time, the community appears to have been a very happy one. We need not trace its history beyond this point, except to say that the mills are still in existence, and that the village has ceased to have anything exceptional in its character. Mr. Owen's name is well known in connection with his extraordinary schemes of social reform.

In Glasgow and other towns in which the cotton manufacture had been established, no difficulty was experienced in finding plenty of work-people. Little skill was required for many of the operations, and the remuneration was higher than in many other occupations. In course of time the number of persons seeking employment in the cotton mills was so great as to induce the masters to make a reduction of wages. This the work-people endeavoured to resent, and troubles arose which disturbed the harmonious relations hitherto existing between employers and employed. In the year 1787 the masters entered into a compact to reduce the price paid for weaving certain kinds of cloth, and the new scale of payment was considered at a conference in which both parties were strongly represented. The decision arrived at being adverse to the weavers, they determined to resist the action of their employers. For this purpose a Trade Union was established, and meetings were held at Glasgow, at which the matters in question were discussed in rather menacing language. The Union drew up its own scale of prices, which every member was bound to adhere to at his peril, and it was agreed to expel from the trade such masters as had made themselves particularly obnoxious. This they sought to accomplish by preventing any member of the Union from working for such masters on any conditions. The men on strike paraded the streets, and on several occasions broke into riot. On one occasion the military were called out, and on the mob refusing to disperse after the reading of the Riot Act, a charge was made upon them, and several persons were killed, and others wounded. This damped the spirits of the operatives, and they gradually withdrew from the Union and accepted the terms of the masters. From time to time, however, attempts were made to obtain an increase of wages; but nothing remarkable occurred until the year 1809, when the weavers of Scotland, in conjunction with those of Lancashire, applied to Parliament for a Bill to limit the number of apprentices, and fix a minimum for the price of labour. Deputies were sent to London to support the application, and the whole circumstances of the trade were investigated by a committee of the House of Commons. The result of the inquiry was that the House declined to interfere, and the weavers got no redress. Two years later the Scottish weavers approached Parliament on their own behalf with a similar proposal, but with no better result. Their next step was to propose to the masters the formation of a joint committee, who should have power to fix the rate of wages. A committee was formed, but no agreement could be arrived at. The perseverance of the weavers was not yet exhausted, however, and they entered an action in the Court of Session to try the relevancy of some old Acts of Parliament which bore upon the relation of employers and employed. The relevancy of the Acts was affirmed by the Court, but the action was fruitless, owing to the attitude of the masters, who refused to recognise the decision of the judges. Soon after the close of the action, 40,000 weavers struck work, and remained out for nearly two months, but in the end yielded to the conditions imposed by the masters.

Discontent was not confined to the weavers. In the year 1806 the spinners found it necessary for the protection of their interests to form a Union. This organisation conducted its operations in secret; but they became so harassing to the masters that the latter determined to curtail its influence, and in 1810 closed their mills against all such operatives as refused to sign a declaration renouncing the Union and its claim to dictate to the masters whom they should employ. This virtually crushed the Union for a time; but between the years 1816 and 1824 it was revived, and under its auspices riotous proceedings of a very serious character broke out on several occasions. The desperate character of the Unionists may be gleaned from the following form of oath which all of them took :—"I, A. B., do voluntarily swear, in the awful presence of Almighty God, and before these witnesses, that I will execute, with zeal and alacrity, as far as in me lies, every task or injunction which the majority of my brethren shall impose upon me in furtherance of our common welfare, as the chastisement of nobs, the assassination of offensive and tyrannical masters, or demolition of the shops that shall be incorrigible; and also that I will cheerfully contribute to the support of such of my brethren as shall lose their work in consequence of their exertions against

tyranny, or renounce it in resistance of a reduction of wages. And I do further swear that I will never divulge the above obligation, unless I shall have been duly authorised and appointed to administer the same to persons making application for admission, or to persons constrained to become members of our fraternity." It was not to be wondered at if that under the existence of such a combination, outrages against the persons of objectionable masters and workmen became frequent. Several were shot at repeatedly, and others were disfigured for life by having vitriol thrown upon their faces. Nobody was killed outright by the desperadoes, but a number were badly wounded, and the mills of three or four masters were set on fire. A conspiracy to murder one mill-owner and five spinning-masters in Glasgow was discovered in 1823. When the troubles of the period referred to were got over, only slight disturbances of the relations between employer and employed occurred till the year 1837, when a general strike took place, which lasted fifteen weeks, and was marked by outrages of a serious character, one man having been murdered, and a woman frightfully burned with vitriol. It was calculated that the loss, direct and indirect, which resulted from this strike was upwards of £160,000. Since that time there have been repeated strikes and misunderstandings on the wages question in the cotton manufacture of Scotland, but they have been conducted in a more orderly way.

There are still to be met in the West of Scotland veteran hand-loom weavers, whose eyes brighten at the recollection of the palmy days of the trade about the time the battle of Waterloo was fought. There were then in Glasgow and suburbs no fewer than 20,000 hand-loom weavers, chiefly engaged in the cotton industry. These men were the best paid and most influential among the working classes. They devoted only four days a week to the loom, but the most skilful of them were in that time able to earn from £4 to £5. As the power-loom came into use, the hand-loom was superseded, and in 1849 there were not more than 5,000 hand-looms in Glasgow and district, while the wages of the operatives for a full week's work rarely reached £1, and in many cases did not exceed 12s. At the present time the hand-looms do not number more than 500, and most of these are employed in weaving patterns for production in the power-loom.

A few years ago a movement was set on foot for the establishment at Glasgow of a weaving school, in which the highest technical knowledge should be imparted. The institution was opened in September, 1877, under hopeful circumstances, and it is now in a fairly flourishing condition. Under the guidance of skilful teachers a number of young men have been, and are being, instructed in the use of the loom in dealing with fibres of all kinds, and the manufacturers of the district now hope to recover the ground they have lost in competition with their rivals in various Continental countries. The Clothworkers' Company has bestowed on the new institution a liberal endowment, and this, with help from other sources, has ensured the pecuniary success of the undertaking.

It is a remarkable fact that the cotton manufacture has not extended much in Scotland during the last thirty years. In 1850 there were 168 cotton factories in the country, distributed as follows:—Aberdeenshire, 2; Ayrshire, 4; Bute, 4; Dumbartonshire, 4; Kirkcudbrightshire, 1; Lanarkshire, 94; Linlithgowshire, 1; Perthshire, 3; Renfrewshire, 51; and Stirlingshire, 4. These contained an aggregate of 1,683,093 spindles, 23,564 power-looms, and employed 36,325 persons. In 1861 the cotton factories numbered 163, containing 1,915,398 spindles, and 30,110 power-looms; and employing 41,237 persons. In 1879 there were 89 factories, with 1,487,853 spindles, 2,265 power-looms, and employing 29,775 persons.

The embroidering of muslin was for a considerable time a branch of the cotton manufacture in Scotland. When the spinning-wheel was superseded by the jenny and mule, a large amount of female labour was left unemployed, and among the arts introduced to provide occupation was the embroidering of muslin in imitation of lace. Several firms in Glasgow devoted attention to this branch, and in their hands it gradually developed to somewhat imposing dimensions. Of the firms which first embarked in the trade to any extent were those of Messrs. John Mair and Co., of Glasgow, and Messrs. Brown, Sharp, and Co., of Paisley, and they gave much attention to the getting up of attractive designs, and training sewers. They sent work and instructors into various parts of the West of Scotland. The young women of Ayrshire showed special aptitude for the work, and their productions soon came to have a name in the market. Schools for giving instruction in muslin-sewing were opened in several quarters, and in them girls received three months' preliminary training. For work done after that time a small payment was allowed, and when the mysteries of the art were

fully acquired, the pupils left, and carried on their work at their homes. About the year 1830 the Glasgow sewed muslin manufacturers began to send work to Ireland, where there was an abundance of cheap female labour to be had. In a short time the Irish work began to compete strongly with the Scottish, and for a time the Irish peasant population was greatly benefited by the money earned in sewing. Sewed muslins came into extensive use on the Continent and in America, and the manufacturers realised handsome profits on their enterprise. The trade reached its height in 1857, at which time a single Glasgow firm—that of Messrs. D. and J. Macdonald—was sending out sewed muslin to the value of half a million sterling a year. This firm employed about 30,000 needlewomen in various parts of the kingdom, and at their great warehouse in Glasgow 2,000 persons found occupation in preparing, giving out, receiving, dressing, and making up the goods.

A commercial crisis in America, and other causes, combined to produce a state of matters, towards the close of 1857, which told severely on the sewed muslin trade, and, indeed, may be said to have completely crushed it. In subsequent years it rallied to some extent, but the invention of embroidering machines and novel modes of ornamenting articles of apparel have prevented muslin-sewing from again becoming an occupation for more than a comparatively limited number of persons.

WOOL AND WORSTED.—XXIV.

BRADFORD: ITS TRADE AND SPECIALITIES.—SECOND PAPER.

By William Gibson.

FOR fifty years after the restoration of the worsted manufactures in the West Riding, Bradford was chiefly noted for its excellent yarns and shalloons, and it was only towards the close of the eighteenth century that she began to put forth her skill in other departments. Within thirty or forty years, however, she had not only out-distanced Norwich in her own specialities, but introduced a host of novelties which have, for the most part, retained their pre-eminence until now. Among those goods manufactured forty years ago may be mentioned merinoes, Saxony cloth, Orleans shalloons, moreens, plainbacks (figured and uniform), crapes, coburgs, and mixed goods in flowers, checks, and stripes. In addition she exported large quantities of yarns to Norwich for the specialities of that town, such as bombazines, crapes, and camlets. Many of the Huddersfield manufacturers preferred Bradford yarns to any other for their fancy goods. Kidderminster and other carpet towns sent here their orders for the special kinds of yarn used by them; and the Rochdale baize manufacturers were almost exclusively supplied with yarn from the same emporium. As was stated in the chapter on shawls, the centres of these goods were all woven in Bradford, and in many instances the weft for weaving the borders. Besides all this, large quantities of pieces in the white and grey were sold to merchants—of whom the late Henry Forbes was the forerunner—to be dyed and finished in other towns, and for years there had been an ever-growing export trade as well in undyed as in finished pieces and yarns.

A few words of description will make the reader acquainted with the chief distinctions between these various classes of woven fabrics. Shalloons are woven from Lincolnshire and Yorkshire long-stapled wool of the finest qualities, with a single warp and weft, but twilled on both sides, or "full twilled," to use the technical phrase. The pieces are from 32 to 36 inches wide, and 29 yards long. Except that the yarn is finer, they differ now very little from the quality made as early as 1810. They are dyed mostly scarlet and Turkey red, and exported mainly to the east of Europe and Asia. Says very much resemble shalloons, except that they are stouter and closer woven. The pieces are also wider and longer, being 42 inches by 42 yards. This class of goods is mostly dyed black, and exported to Roman Catholic countries, where it is largely used for the ordinary attire of priests. Russells are a kind of lasting, woven with a double warp and single weft, 27 inches broad and 28 yards in length. They are carefully finished and glazed, and are used for boot and shoe uppers, ladies' petticoats, and men's waist-

coats. Lastings and Serge de Berri are the same class of fabric. The former is heavier than Russells, and the latter stouter than lastings. Both are woven in narrower widths, rarely exceeding 18 inches, and the best mixture of wools for the purpose is Lincoln and Nottinghamshire. Calimancoes are plain and striped goods, woven with single warp and weft, finished and glazed, 17 inches wide by 29 yards long. Tammies are composed of deep-stapled Lincoln and Yorkshire wools, spun to high numbers in the yarn, carefully finished and glazed. They were, and still are, popular for ladies' dresses. At the York county ball in 1808, for example, it was *de rigueur* that all the ladies should wear a robe of this material, and as they were to be had in many hues and colours, the room, according to eye-witnesses, had a brilliant appearance. Wildbores are stuffs of the same class, only stouter in body. Worsted camlets differ considerably from the ancient woollen material. They are either plain or twilled, 18 to 27 inches wide, and in pieces 29 yards long. Some are woven with a single warp and weft, others with double warps. Generally speaking they leave the loom in the grey, are dyed in the piece, and hot-pressed. This class of goods is very largely exported to the East Indies and China, and is used to a considerable extent at home for ladies' cloaks and jackets. Moreens were a stout heavy material, in great demand for furniture and furnishing. They were sometimes embossed, but mostly watered, 28 inches wide, and 24 yards to the piece. Bombazine is woven with a silk warp and worsted weft of mixed Norfolk and South Down wool. Plainbacks, as their name indicates, have one side plain and the wearing surface twilled, and, as we have just said, they paved the way for merino, which they closely resemble. Dobby was a figured material, woven, as has been described, by aid of a wooden machine instead of a drawboy. Saxony is a soft, full-bodied, glossy material, in which the warp is half-bred English merino and Australian wool, and the weft closely spun South Down. As our readers know, it is a favourite material for ladies' dresses. Gambroons, first introduced by Messrs. Buckley, of Todmorden, composed of a thread of cotton and one of wool twisted into yarn, were the first form of a class of goods since known as mixed stuffs, and used for light overcoats for summer wear.

Bradford manufacturers were wise when they embarked upon the fabrication of fancy stuffs; for though they might have held their own in producing fine woollen fabrics, they rightly judged that cheap attractive mixtures would command and retain popularity. The tendency in the woollen trade from the first had been in the direction of fineness of material rather than lowness of price, and of the worsted merchants to produce a good and attractive texture at a low figure. We have already called attention to several notable eras in the trade of the town, and we have now to advert to two others, perhaps more important than any two hitherto mentioned—the introduction of alpaca and mohair, and the substitution of cotton for worsted warps. In a former part of this work we narrated at length the share Sir Titus Salt took in founding and extending the trade in alpaca. He was speedily followed by other manufacturers, who saw that the new fabric was likely to meet with a large sale. Among the more prominent of these may be mentioned J. Foster and Son, Black Dyke Mills; Messrs. R. S. Ackroyd, Bradford; I. and J. Craven, Keighley; Milligan and Jowett, Bingley; and A. and S. Henry. All these houses made up more or less mohair when the difficulties attending the spinning and dyeing of alpaca had been thoroughly mastered, and in a very few years about as much of the former was used in the district as of the latter. The imports of mohair, which stood at 575,523 lbs. in 1843, had risen to 3,251,806 lbs. in 1853, and the increase since has been proportionate to that of alpaca. The effect produced upon the trade of the town by the novelties in these materials is almost incalculable; and, during the last twenty or thirty years, the varieties of goods brought into the market by the firms named above, and others hardly less notable, are almost bewildering. And people have now become so fastidious that the wonder is that so few of the Bradford novelties have been failures. Of course it has occurred now and again that some patterns and mixtures have turned out a dead loss; but, on the whole, Bradford has been singularly successful —and this applies to her manufacturers all round— to feel when buyers have had enough of one kind of material, and in being ready with some fresh dainty to whet the flagging market. Indeed, this is one of the secrets of her success. The great houses have had the credit of all the "hits," and while, no doubt, the principals may have often deserved some portion of the praise, the real authors of novelties have in many cases been men whose names are not so much as known outside the firms in which they are engaged. Interesting would be the story of those private but most deserving men, whose good taste and keen artistic sense have conceived the kind of

article that has led the manufacturers to fame and fortune. This, indeed, is true of almost every department of labour, but particularly so of the stuff trade.

Of all the expedients resorted to in the worsted manufacture, perhaps the most important is the introduction of cotton warps; and, with reference to it the remark just made receives a startling confirmation. America, till within recent years, when she began to produce her own wearing materials, was one of the largest buyers of Manchester and Bradford goods, and it was a wholesale dealer on the other side of the Atlantic who threw out the hint that led to the substitution of cotton for worsted warps in light materials. At various periods in the history of the woollen manufactures, mixtures of silk and linen have been tried with more or less success, but it was only when the manipulation of cotton approached its present perfection that this vegetable wool—for it is really that—came into use along with that of the sheep. America longed for some kind of light material for wear during the hot summers, and we believe the first Englishman who tried to produce a material suitable was a Manchester cotton-spinner. He had the right idea when he experimented with cotton-warp, but, unfortunately the dyers of his time were too ignorant to enable it to be carried out with success. The first manufacturer who succeeded in making a marketable union cloth was Joseph Barratt, first of Newton Heath, Manchester, and subsequently of Huddersfield; but practically Bradford realised most of the profit and fame connected with the discovery. It may be that Mr. Barratt had heard of the earliest attempt to mingle cotton with wool, or seen some of the goods, or it may be that he conceived the idea quite independently; but, at any rate, he was the first who succeeded with what has since been known as Orleans cloth—so called because the town was one of the largest customers for it in the early days of its manufacture—and there can be no doubt that from it come all subsequent classes of unions. Fortunately we are in a position to give all the essential facts of Mr. Barratt's connection with Orleans cloth. In the usual course of business he went to America in the spring of 1825, and the desire for a light summer cloth was mentioned to him. One house, with which he had relations, offered, in case he produced an article which met the public taste, to take as many pieces as he could make. On the homeward voyage his mind was entirely occupied with the offer, but the real question was what kind of material should he attempt to make. After much cogitation he thought of trying a cotton-warp so hidden in the woollen weft as to be invisible, yet by its superior fineness materially reducing the weight of the cloth. On arriving home he mentioned the matter to at least one friend—we believe the person who had first tried the experiment. The latter at once dissuaded him from the proposed attempt, and used the very powerful argument that his own best endeavours had resulted in almost total loss, the goods having brought in the market 50 per cent. less than the cost of the raw material. The failure was at least partially due to the difficulty of dyeing the mixture. Cotton could be dyed, as wool could, alone; but the materials then known as mordants for the one were neutralised by those used for fixing colours in the other. Mr. Barratt, however, was not to be baulked, and went to the best dyers he knew. At first he tried dyeing the cotton yarn before weaving, but could not succeed—the same colours showing so differently in the two materials. Without going into too many details, it may be said that eventually a means was found. Cotton dyed indigo blue it was found would, when mixed with wool in the piece, dye black, blue, and, with great care, dark green. Afterwards it was discovered that brown and drab warps would dye purple and drab. His first sample exactly suited the American merchants—though, compared with subsequent productions, it was very inferior both in colour and quality—and he received from two houses orders for as much as he could weave, provided he neither showed nor sold to any other. The consequence was that only limited quantities of the article were sent into the market. But other wholesale merchants determined to have the same class of goods, and they went to the Bradford manufacturers. Although much behind Mr. Barratt at first, they soon produced materials almost if not equally as good, and in 1837 large quantities of orleans began to be sent out. Mr. Barratt's earlier efforts were confined to a plain cloth with one thread with cotton in each dent of the reed, and this when finished had the appearance of a very fine pile; but, subsequently, he produced single and double twills, diagonal pile—which he called Astrakhan—and, finally, crape cloth. The demand for all kinds of orleans only became notable in 1836, but in the following year Mr. Milligan was weaving considerable quantities of it. The Bradford dyers speedily extended the range of hues from the darker to the lighter, and even made excellent mixtures as early as 1840. Mousselaine

de laine—of cotton warp and worsted weft, not like the French article, all wool—was the first variation from orleans. At first this material was produced exclusively on the hand-loom, and chiefly in Colne, Lancashire, whose weavers were at that time as noted for their manipulation of cotton as wool; but since then a superior article has been woven quite easily on the power-loom. Manufacturer after manufacturer took up the hint. Dyers everywhere turned their attention to hiding the presence of the vegetable admixture, until almost every description of stuff was made with a cotton warp, and many woollen manufacturers adopted it for cheap cloth.

As to the Bradford novelties, almost every manufacturer has his own specialities, while every year produces hosts of new patterns and combinations. Without pretending to catalogue them, we may conveniently take a single house, and from the more important features of its history gather an idea of the various classes of fresh stuffs that have either formerly been largely sold or are in general demand at present. Mr. Robert Milligan has, however, written a narrative of the chief productions of his firm from 1836 to 1856, and we cannot do better than present our readers with the substance of it, with such additions from other sources as are within reach. Up to this time (1836) Bradford manufacturers, as we have already stated, had chiefly been engaged in making plain and figured merinoes, plainbacks, shalloons, and other all-wool stuffs, but in that year cotton warps had already attracted considerable attention. Pieces then ranged at prices between 50s. and £4 10s. per 28 yards, a yard wide in the grey, *i.e.*, undyed. The numbers of cotton generally used were from 50 to 60, the price of the former being from 2s. 3d. to 2s. 7d., and the latter about 2s. 8d. per lb.; but the cost of dyeing and finishing was so great that orleans stuffs were not so very much cheaper than all-wool ones. However, within three years a complete change had been effected. In 1839, for instance, double twills, all worsted, were worth £9 15s. a piece, and in the same year orleans six quarters wide was sold for 70s., and cloth half the width for 40s. Mr. Milligan gives us an incident which occurred about 1840, which shows the intense competition that went on among rival buyers for the best makers' goods. He says that a Quaker and a young merchant came to blows in order to be first in the field on the opening of his doors on Mondays and Thursdays! This keen demand led, as might be expected, to extensive over-production. Hundreds of persons took the field either as makers or buyers —the market was glutted, and for ten years, between 1841 and 1851, the demand for certain classes of goods varied so materially as at times almost to ruin otherwise successful houses. In the former year mohair began to be used as warps for ladies' dress pieces, and the prices of the various union mixtures compare favourably with alpaca and mohair goods generally, and with all-worsted fabrics. Worsted double twills were worth on the average 6s. per yard; plain alpacas from 38s. to 80s. per piece (28 yards); Parisiennes, 30s. to 59s.; silk warp alpaca, 38s. to 75s.; mohair lustres, 48s.; checked ditto, 52s. to 56s.; $\frac{3}{4}$ alpaca grograms, 72s. 6d.; and alpaca checks, 56s.; $\frac{6}{4}$ orleans was worth 30s. to 62s.; paramattas, $\frac{3}{4}$ to $\frac{7}{4}$ wide, 38s. to 75s.; $\frac{3}{4}$ diagonal twills, 38s.; $\frac{3}{4}$ summer cloths, 34s. to 47s.; Russell cords, 42s.; and $\frac{6}{4}$ merinos (cotton warps), 44s. In other words, while yard wide all-worsted goods ranged on the average 6s. per yard, alpacas were from less than 1s. 1d. to 2s., and orleans stuffs, double the width, very little more. Paramattas began to give way to what have since been known as coburgs, and these were merely a lighter kind of paramatta. The difference between coburgs and all-wool stuffs, such as merino and cashmere, consists in the back of the former showing the cotton warp. The coburg is a true plainback in union, since it has been made with a single cotton warp. In 1843 the alpaca trade was chiefly confined to Salt, Milligan, and James Whitely, but within a few years the two last-named had ceased to make these stuffs, and from that time John Foster and J. and R. Turner have taken their place. In course of time, too, what had previously been called orleans was known as demi-lustre and lustre. In 1845 the novelties most run upon were stuffs of the grogram species, princettas of all sorts, and orleans. Princettas were a similar material, only stiffer and sharper to the touch than the paramatta. The orleans weft about this time was spun of the finest York and Lincoln wools, bright-haired, and such as had previously been exclusively used for warps. In this year Mr. Milligan states that his firm had above one hundred kinds of cloth upon their list. Princettas were worth about 27s. a piece. In 1847 checked orleans were in considerable demand, manufacturers having succeeded in accomplishing the yarn dyeing, so that the two materials of which the cloth is composed did not show in the piece. These checks were worth 35s. a piece, but commoner cloths made to imitate them were not worth

more than 17s. to 20s. a piece. These checks were made in consequence of the large sale of alpaca stuffs of a similar pattern which had been much in vogue. The following year the checks gave place to stripes. All kinds of striped goods were made,—alpaca with silk and satin stripes, orleans with silk stripes, and even striped coburgs. In the same year a new kind of coating material began to be made. It was a grogram woven of black worsted on a thick cotton warp, round which was twisted fine threads of white, yellow, or gold silk. This warp produced a speckled effect in the piece. It was also in this year that Mr. Salt produced his alpaca umbrella cloth and his flowered alpacas. Alpaca umbrella cloth has held its own ever since, but now the cheaper sorts are made of alpaca mixture, and since 1848 a material called zanella cloth, which has a cotton warp, has been largely made. Flowered alpacas have their fashionable periods, as indeed do all embroidered goods for ladies' dresses. At that time silk used to be woven loosely across the back of the piece in a swivel loom. The weaver used one large pair of shuttles for the alpaca weft, and eight or ten smaller ones, or more, if the flowers required a greater diversity of shade, for the sprigs. Milligan afterwards imitated these in other materials, as well as in alpaca, by a process which he patented. He wove-in the silk white, and dyed the flowers their natural colour in the piece. Since this improvement the old-fashioned "coloured mottled" alpaca, as it was technically called, has ceased to be made. The flowers are now stamped or printed on all materials on which they are used. This is done by the process patented by Mr. Milligan, for which the jurors at the Great Exhibition awarded him a gold medal. About 1856 Russell was imitated in softer materials, called Persian, Circassian, and Russian cord, and by that time alpaca mixtures had a firm hold in the market. These mixtures were a great boon to alpaca manufacturers, as they enabled them to use up the inferior and low classes of the raw material. Low alpaca had long been a drug in the market and a loss to the manufacturers of the best kind of cloth, but the mixture trade enabled them to get rid of it. At first, however, the mixtures did not promise to become a permanent feature of the Bradford trade, from the fact that they were sent into the market as true alpacas.

We reproduce, in order to show the number of cloths which have held their own for a long time, an extract from the list of goods kept in stock by a Bradford merchant a few years ago. The complete list is too long, but the chief features, as will be seen, present a very large variety :—$\frac{5}{8}$ and $\frac{3}{4}$ Amiens ; $\frac{6}{4}$ alpaca lustres, plain and figured ; $\frac{5}{8}$ buntings ; $\frac{3}{4}$ camlets ; $\frac{4}{4}$, $\frac{6}{4}$ Mexican, American, Dutch, and China makes; 30 in. cambletees ; $\frac{3}{4}$ and $\frac{6}{4}$ crapes in worsted union, mixed and grandelle ; $\frac{3}{4}$, $\frac{4}{4}$ Cubicas; $\frac{3}{4}$ crape coatings; $\frac{6}{4}$, $\frac{7}{4}$, and $\frac{8}{4}$ coburgs ; $\frac{3}{4}$ to $\frac{6}{4}$ damasks in worsted and union; $\frac{3}{4}$ to $\frac{6}{4}$ merino yard wide worsted alpaca aprons ; yard wide and $\frac{6}{4}$ worsted dobbies ; $\frac{6}{4}$ French figures ; $\frac{6}{4}$ full twills, all-worsted and cotton warp ; $\frac{3}{4}$ grograms ; $\frac{3}{4}$ plain and fancy gambroons ; $\frac{3}{4}$ and $\frac{6}{4}$ linings ; $\frac{3}{4}$ and $\frac{6}{4}$ Italian crapes ; $\frac{3}{4}$ figured cloths, silk and cotton warp ; $\frac{3}{4}$ and $\frac{6}{4}$ worsted and union; plain and fancy lastings; $\frac{3}{4}$ moreens; $\frac{3}{4}$ mohair figures; $\frac{6}{4}$ merinoes; $\frac{6}{4}$ and $\frac{7}{4}$ orleans lustres, plain and figured; $\frac{3}{4}$ and $\frac{6}{4}$ princettas, worsted and union; yard wide plain-backs, half twill, full twill ; $\frac{7}{4}$ queen's cloth ; $\frac{3}{4}$ figured Russells, worsted, union, and silk and cotton warp, or Italian cloth ; $\frac{3}{4}$ serge de Berri, worsted and union; yard wide shalloons ; $\frac{6}{4}$ plain shotts, silk figured and striped ; 40-inch says in three degrees of fineness in worsted and union ; $\frac{3}{4}$ stockinettes, worsted, union, and grandelle ; $\frac{3}{4}$ elastic stockinettes ; $\frac{3}{4}$ to $\frac{6}{4}$ summer cloths ; $\frac{4}{4}$ to $\frac{6}{4}$ wildbores ; $\frac{3}{4}$ tammies; yard wide Tournay cloth ; and a variety of cloths for South America and other foreign markets, amounting in all to over one hundred distinct classes of goods.

Continuing to measure the growth of the Bradford trade by the amount of drawback, we may give a few of the figures between 1840—50. In the first-named year it was £8,000; in 1845 it had risen to £13,051 10s. 6d.; and in 1850 to £14,059 17s. Put in another form, Bradford used as much wool in 1850 as the whole of the West Riding of Yorkshire had manufactured thirty years before. Another mark of the growing trade arising out of superiority of manufacture is the ever-increasing export of pieces. There were exported in 1816 593,308; in 1826, 1,138,588; in 1836, 1,718,617; and in 1846 nearly 2,300,000. Since then the increase has been even greater. The same story is told by the export of yarns, which began about 1820. In that year 3,924 lbs. valued £810; in 1830 the value had risen to £122,430, representing 1,108,023 lbs. of yarn; in 1840 no less than 3,796,644 lbs. of yarn were exported, valued at £252,957; but in 1842 the declared value of exported yarn was £637,305, or about 8,000,000 lbs. of yarn. The last-mentioned figures afford an indication of the progress that has been made during the last thirty years.

HEMP, FLAX, AND JUTE.—XXIV.

GENERAL SURVEY OF THE LINEN TRADE.

By David Bremner, Author of "The Industries of Scotland."

In closing the series of chapters under the above heading, it may, perhaps, be well to take a glance at the recent condition of the linen manufacture, and note various facts of interest connected therewith which have not been incorporated in the previous chapters. In his interesting account of the linen manufacture, Mr. Hugh M'Call, of Lisburn, a high authority on all matters pertaining to that industry, has given the following concise review of the trade during the eighteen or twenty years preceding 1876:—

"The intestinal war in America was the means of creating great fluctuations in the linen trade of the United Kingdom; and even after peace had been proclaimed, there were many changes in the manufacture which, taking the intermediate period down to 1876, present very interesting features of national industry. It will be recollected that the remarkable years of 1862–3 brought with them the cotton famine—an era in Britain's history which will never be forgotten by those who witnessed the terrible effect of that day of desolation. Mills were put on half-time, and ere the close of 1862 many of them had closed altogether. The factories shared the same fate, and ultimately tens of thousands of operatives were reduced to something approaching semi-starvation. But while production of cotton goods was brought down to a mere moiety of the turn-out of 1860, demand increased enormously for those low lines of linen which then came into play as substitutes for calico. Prices rose rapidly, and all the power of the steam loom and all the energies of hand-weavers could barely meet current requirements. Home markets absorbed immense lots of coarse fabrics, while for the foreign trade there was any degree of activity in warehouses. In 1861 there were 110,124,998 yards of plain goods exported from this kingdom, and that aggregate gradually rose until the year of extra activity (1866), when 232,837,903 yards were sent away. A partial lull came over the trade in the following year, which continued for the two succeeding seasons, when better times again marked the history of the manufacture, and in 1872 the exports had gone up to 233,838,338 yards. Very dull days followed, and for 1874 the total extent of business done with foreign and colonial customers was 146,791,516 yards. In the meantime the growing taste for printed goods was giving great stimulus to that department of the linen manufacture. The exports of this variety of goods in 1861 only reached 2,617,576 yards; in 1864 there was an aggregate of 15,998,708 sent away, and in 1876 the figures were 13,205,640 yards. It will be seen, therefore, that, dull and inactive as was the general trade during the latter year, the exports of printed linens were 500 per cent. above those of 1861. During the fifteen years that have gone by since 1861 there has been a very satisfactory improvement going on in the demand for linens throughout nearly all the British colonies. In course of that year the Canadian Dominion took from our merchants and manufacturers goods to the value of £103,906; in 1866 the exports to the same colony amounted to £282,263, and to £261,939 in 1876. To the Australian Isles there were sent in 1861 linens valued at £171,875; in 1866 the amount had increased to £323,316, and in 1876 a further advance was made, the figures standing at £357,638. The United States, the leading seat of sales for British and Irish linens, took goods valued at £730,334 in 1861—that was the first year of the war; an immense increase was experienced in the succeeding year's trade, and this increase went on till 1866, when the value of goods sent to the Republic of the West had risen to £4,412,084. A gradual decline followed, and in 1876 the value of all the exports to the United States had gone down to £2,900,336; still the figure very far exceeded that of the exports to any half-dozen of the other customers of Britain. The Spanish West Indies have been doing a progressive business in flaxen fabrics. There was a total export for 1861 valued at £302,692; in 1866 the amount was £643,061, and in 1874 the goods taken off were valued at £786,064. Germany, from whence came over in early times the men who taught Irish bleachers the best lessons they had ever received in the art of finishing linens, took in 1861 goods valued at £466,952; again to the value of £524,271 in 1866, and a total of £569,332 in 1876. Our neighbours over the Straits imported from Britain linen valued at £184,588 in 1861; in 1866 they imported £282,550, and in 1876 they took a gross value of £421,665."

Since the foregoing was written the linen manufacture shared with other branches of business in the severe and wide-spread depression of subsequent years. The total value of the linen goods exported in 1875 was £7,272,920, and from that point it dropped by stages to £5,534,776 in 1878.

Mention has already been made of the Irish Flax Supply Association and its operations. Not the least valuable service of this organisation is the issue of an annual report embodying a mass of information on the trade which cannot fail to be useful as well as interesting to flax growers, manufacturers, and merchants. From the report for 1878 we glean what follows.

The percentage under flax to acreage under crop in Ireland and the Province of Ulster in the following years, was:

	Ireland.	Ulster.
1869	4·11	11·17
1870	3·45	9·38
1871	2·79	7·73
1872	2·22	6·13
1873	2·46	6·82
1874	2·03	5·67
1875	1·90	5·37
1876	2·55	7.16
1877	2·34	6·62
1878	2·15	6·01

The foregoing gives a pretty comprehensive view regarding the area occupied by the flax crop in Ireland, and the next and equally important matter to deal with is the yield per acre and production of fibre. The following shows the average production in 1878:—

	Acres under Flax.		Stones per Acre.	Produce in stones of 14 lbs. each.
Ulster	108,864	at	31·06	3,381,340
Connaught	1,172	„	36·07	42,274
Munster	965	„	32·99	31,835
Leinster	807	„	33·97	27,417
Ireland	111,808	„	31·15	3,482,866

Subjoined is a summary of the yield of flax per acre in Ireland and in each province in the years named. The fluctuations are very remarkable, and were chiefly to be accounted for by the state of the weather and the quality of the seed used:—

	1871. Stones.	1873. Stones.	1875. Stones.	1877. Stones.	1878. Stones.
Ulster	13·56	25·00	32·73	28·53	31·06
Munster	21·91	31·53	37·22	28·80	32·99
Leinster	17·17	29·76	35·65	32·29	33·97
Connaught	17·66	24·94	39·04	29·24	36·07
Ireland	13·88	25·15	32·87	28·57	31·15

According to the Agricultural returns issued by the Board of Trade, the following was the acreage under flax in Great Britain in 1877 and 1878, showing a decrease in the latter year compared with the former.

	1877. Acres.	1878. Acres.	Decrease. Acres.			
England	7,210	7,160	50	or	0·69	per cent.
Scotland	243	98	145	„	59·67	„
Wales	28	3	25	„	89·29	„
Great Britain,	7,481	7,261	220	„	2·94	„

Taking the yield per acre at the same as in Ireland, viz., 31·15 stones, the produce of the flax crop in Great Britain in 1878 would be 1,414 tons of fibre.

In the following summary, which may be useful for comparison, the most recent acreage is given, and the estimate of annual production in the various European flax-producing countries, and Egypt, is based, where practicable, upon average yields, and where no data exist a moderate yield is assumed:

	Statute Acres.		Stones.		Tons.
Austria	233,164	at	21·48	per acre	31,302
Belgium	140,901	„	33·59	„	29,580
Denmark	17,686	„	20·00	„	2,211
Egypt	15,000	„	20·00	„	1,875
France	194,571	„	34·84	„	42,368
Germany	530,642	„	22·50	„	74,621
Greece	957	„	20·00	„	119
Great Britain	7,261	„	31·15	„	1,414
Hungary	24,888	„	20·00	„	3,111
Holland	50,564	„	31·77	„	10,040
Italy	201,023	„	18·14	„	22,791
Ireland	111,808	„	31·15	„	21,768
Russia	1,928,568	„	20·00	„	241,071
Sweden	37,500	„	20·00	„	4,688
	3,494,533				486,959

The decrease in the number of scutch mills in Ireland, more especially of small mills, during the last ten years has been very marked. Since 1869 there has been a decrease of 330 mills, or 21·4 per cent. The scutch mills in Ireland came under the provisions of the Factory and Workshop Act of 1878 on the 1st January, 1879, and the restrictions which this Act imposes will (according to the report) have the tendency to cause more mills to close, and thereby limit the facility of farmers having their flax prepared for market; the probable effect will therefore be to diminish the production of a raw material necessary for the maintenance of a most important national industry.

In the years named the number of spindles contained in mills in Ireland was—

1850	396,338	1876	920,677
1861	592,981	1878	918,182
1871	866,482	1879	906,522

In 1859 there were	3,633	Power Looms.
1864	,,	8,187	,,
1871	,,	14,509	,,
1874	,,	19,331	,,
1876	,,	20,152	,,
1878	,,	20,958	,,

With reference to the countries enumerated in the following summary, the record given is the most recent available as regards the number of spindles and looms. The spindles are mainly engaged upon flax fibre, but in some cases those employed on hemp and jute are not distinguished.

	Spindles.	Power Looms.
Austria and Hungary	398,608	500
Belgium	289,000	4,755
England	291,735	5,624
France	500,000	23,036
Germany	318,467	8,000
Holland	7,700	1,200
Ireland	906,552	20,958
Italy	55,000	750
Russia	150,000	2,500
Scotland	275,119	18,529
Sweden	3,810	98
Switzerland	9,000	—
Spain	—	1,000
	3,204,991	86,950

The record of exports of linen yarns from the United Kingdom from the year 1869 till 1878, inclusive, marks a progressive decline, while the imports indicate an increase. The exports in 1878 were 3·8 per cent. in quantity and 6·1 per cent. in value under those of 1877, and 1877 contrasted with 1876 also marked a diminution of 13·6 per cent. in quantity, and 10·9 per cent. in value. The exports to Belgium and Germany in 1878 alone showed an increase in quantity and value; but the percentage in value being in excess of quantity indicated that the yarns exported were of a higher quality than those exported in 1877. The exports to France also indicated that the yarns sent in 1877 were not of so high a quality as those which were exported in 1878, in which year the quantity exhibited a decrease of 0·6 per cent., whereas the value showed an increase of 8·7 per cent. Spain, which took the largest quantity of yarns, marked in 1878, compared with 1877, a decrease in quantity of 10·4 per cent. and in value of 21·1 per cent., and in 1877 the quantity and value exported were respectively 20·1 per cent. and 15·9 per cent. under 1876.

Our customers for linen manufactures embrace all the civilised peoples of the world, and the extent of their respective transactions will be learned from the following table of the declared value of linen manufactures exported from the United Kingdom in 1861, 1866, and 1877. These years are selected because it is not necessary to go farther back than the first-mentioned, while the second shows the highest figure ever reached, and the third may be regarded as marking a point to which the trade would rapidly attain were the depressing causes at work in 1878–79 quite removed. The large export of 1866 was, as already pointed out, owing to the American war, which caused the price of calico to go up to a point at which linen was able to compete with it successfully:—

Countries.	1861. Value.	1866. Value.	1877. Value.
	£	£	£
Austria	19,647	21,181	8,474
Argentine Republic	46,111	166,018	77,554
Australia and New Zealand	171,875	323,363	382,582
Belgium	42,146	22,708	47,621
Brazil	208,301	490,338	150,864
British North America (including Canada)	103,906	282,363	212,127
British West Indies	93,030	154,397	59,384
British Guinea	15,684	32,217	16,202
British India, Ceylon, &c.	127,064	128,711	95,320
China (including Hong Kong and Macao).	29,301	70,911	17,218
Chili	40,769	107,999	26,751
Cape of Good Hope and Natal	29,945	21,802	32,096
Denmark	38,829	55,633	48,345
Danish West Indies	109,979	136,982	30,516
Egypt	27,438	88,421	12,537
France	184,588	282,959	444,139
Germany	466,952	524,271	387,836
Greece and Ionian Islands	10,358	17,187	5,409
Gibraltar	39,488	40,219	6,850
Hayti and St. Domingo.	73,563	126,866	54,098
Holland	55,067	48,324	51,575
Dutch Possessions	12,457	44,743	30,869
Italy	163,639	115,810	106,404
Japan	628	2,621	20,189
Mexico	99,200	145,168	109,026
Monte Video	13,557	73,997	35,107
Norway	22,888	36,606	60,892
New Granada	69,482	298,930	82,010
Portugal	36,357	52,192	36,569
Portuguese Possessions.	2,041	5,930	680
Peru	70,958	91,043	23,760
Russia	52,570	26,435	31,221
Spain	117,540	60,844	91,566
Spanish West Indies	302,692	643,061	299,637
Other Possessions	51,762	104,323	74,206
Turkey	22,567	85,585	19,544
United States	730,334	4,412,084	2,379,325
Venezuela	48,927	61,121	63,317
Other Countries	100,701	173,882	202,623
Totals	3,852,341	9,577,245	5,834,443

The report complains of the restrictions placed upon the hours of labour by the Factory Acts, as placing the Irish manufacturers at a disadvantage compared with their competitors on the Continent.

"This is a subject," it says, "which sooner or later must engage the serious attention of those who have the welfare of Great Britain at heart—national prosperity depending upon the maintenance of industrial enterprises." The views of some leading members of the Association with regard to the industry which it is their object to encourage may be gleaned from the following extracts from a report of their general meeting.

Mr. Ewart said he was one of those who held by the old wish to see Irish spinners supplied by Irish farmers. No country in the world was better able to produce the most useful flaxes; and he held there must be something wrong when they were an importing, instead of a largely exporting, country. He would give them two instances where he thought they were wrong. The first was that the crop was not cultivated more generally over the whole country. It was to be regretted that Connaught showed so large a falling off as 25 per cent., and that the increase in Munster and Leinster was so fractionally small. He had always heard that in the good old times almost every farmer in Ireland sowed a patch of flax, which was spun by his family, and turned into cloth in looms scattered over the country. In those times cotton was not so common, and linen was a fabric in general wear with all classes. The second point in which they were wrong was that the crop was not usually better handled. The steeping process being so critical, and requiring hourly care until it was complete, and the present system of scutching presenting, as it did, too great an inducement to put the flax into market insufficiently and carelessly cleaned, he believed that all parties would gain much by relieving the farmer of these processes, with all their risks, and having them carried out under the supervision of skilled and experienced men, who would give their entire attention to their work. There was no doubt, also, that they lost much in Ireland by destroying the seed in the steeping process, and he had never yet been satisfied with the imperfect experiments which had been made in field-drying flax. He knew that the climate of Ireland presented great difficulties; but, after all, flax farming was the highest branch of agriculture in the country, and gave the best opportunity for turning knowledge and skill to account. He would, however, urge farmers to devote to the flax crop only the land that was in a high condition for the crop; otherwise they would be disappointed at the result.

Mr. Foster Connor said, the Irish linen manufacturers had many difficulties to contend with—higher tariffs in America and in France, and in almost every country with which they did business; the tariffs were altogether against them. In former years the Irish manufacturers used to export largely to the Continent, but that had been considerably withdrawn in late years. Continental countries had supplied their own wants, and the home manufacturers were not able to compete with them. They had also sent some yarns to our market, but, though not to a very large extent, it showed the great advances they had made when they were able to do so. He was not an alarmist so far as the yarns were concerned, for he found on looking into the figures that a good spinning mill of about 30,000 spindles would produce all the yarns which were coming into Great Britain and Ireland. That was not very alarming, and he did not think they need take it into consideration. He knew that some of his friends who were producers of a certain class of yarns would rather see these imports prohibited; but he was a free-trader, and was glad to see them coming in, as it kept their spinners up to the mark.

POTTERY AND PORCELAIN.—IX.

WEDGWOOD'S JASPER WARE—PARIAN—MESSRS. MINTON'S CHINA WORKS, STOKE-ON-TRENT.

By James Francis McCarthy.

Any account of Wedgwood's works would obviously be incomplete which took no notice of jasper ware. In the last chapter allusion was incidentally made to this description of pottery, which owes its origin as an important and fascinating branch of the ceramic art to the inventive skill of Josiah Wedgwood. In its nature jasper ware is vitreous, and barytes enters largely into its composition. Its texture is exceedingly fine, so that the ornamentation which the body of the ware receives is seen to the best advantage. There are two kinds of jasper, the first being Egyptian red and brown, in which nodules are formed with round or vertical-shaped delineations. The second is porcelain jasper,

or clay so altered by heat as to be rendered more fusible. Of the decoration of jasper no fair conception can be realised unless it is seen. It is all effected by the process of modelling; that is to say, the pattern which is needed—whether it be a classical arrangement of figures, a graceful grouping of flowers and leaves, or the imitation of any conventional design—is literally cut out by the artist on plaster of Paris. From this design a model of clay is made, the modeller necessarily being a very skilful workman. Again, from this model a mould, generally in many parts, is formed; and when the liquid, or soft clay, adheres to it and hardens, we have the exact reproduction of the original design. The figures taken from this mould are then, by means of a little liquid clay, pasted on to the body of the ware, and when fired appear, as they should do, in marble-white relief. This relief can be best compared with cameo, which it very closely resembles. The particular charm of this ornamentation consists in its vivid gracefulness—a gracefulness which does not slowly dawn upon the mind as a mental evolution, after long and patient observation, but immediately appeals to the senses with almost sentient force. Flaxman's varied and beautiful designs demonstrate this. His work, of a purely classical order, is at once noticeable for its beauty and its strength. Much as Wedgwood's jasper ware has been famed in the past, it must not be supposed that it has now deteriorated. On the contrary, whilst not departing from Flaxman in the spirit, the artists of to-day have adapted the ideas of their great predecessor to modern thought. The accompanying engraving of Mr. Charles Toft's design, the "Seven Ages of Man," graphically illustrates this idea. The figures are charmingly modelled, cunningly fixed on to the ornaments they adorn, and are fired with patient care.

Design in Jasper Ware: "The Seven Ages of Man." (*After Charles Toft.*)

Somewhat in the nature of jasper ware, but much inferior in kind, is parian. Like jasper it has a vitreous body, and is of fine texture. It is used for ornamental purposes, and is familiar to us chiefly in the shape of vases, large fancy flower-pots, &c. Its ornamentation, except in those articles that are decorated with figures, which would, of course, have to be modelled, is chiefly of a floral description, either in the form of a bordering round the rim of the vase, or on the surface of it. When the flowers do not consist of an elaborate or intricate device, they are formed by hand by youths and girls, and sometimes men. With the aid of a little steel tool, something like a large stocking-needle, the worker with great rapidity changes the small pieces of soft clay which lie on the bench near at hand, into imitation flowers. Taking the clay in one hand, and rolling it into a round lump, he pinches a little from it, deftly plies the tool referred to, and in a second there is a flower formed. When the pattern is completed all the separate parts are combined, and being fixed on to the body of the ware by liquid clay, are ready for firing. When they come out of the kiln these flowers, which appear in relief, are snowy white, but, if necessary, they can afterwards be painted. When we see all this fancy parian work, encircled with flowers so exactly imitated that Nature need not

be ashamed of them as charming copies of her own work, it may be worth a passing thought to remember that two-thirds of this floral decoration is done by boys and girls. Throughout the day, in the midst of eager, earnest labour, and often far removed from the sight of leaf or field, these busy little workers are imitating some of the real flowers of Nature.

Who has not seen or heard of Minton's china? Commoners and peers, rich and poor, connoisseurs, and fond admirers of ceramic gems, who spend little fortunes for the possession of them, the learned in art industry, as well as the less educated in the beauties of manufacture, all are familiar, either directly or indirectly, with the name of Minton in connection with the production of china. Not alone in this country has Minton's china acquired a popular fame, touching every rank and grade of society, from the lord who can give three hundred guineas for a single dinner-service, to the no less enthusiastic purchaser of limited means, who is rich in the contemplation of a pair of vases that may have cost a guinea. Minton's china has penetrated into every important capital in the world, and may doubtless be seen in every court in Europe. On the table of the wealthy it vies with rival specimens of porcelain from Sèvres. And it may be interesting to state that much as has been said of the productions of the great State-supported French porcelain establishment, Minton's finest china—egg-shell china—will bear comparison with it for perfect workmanship. Those who so frequently see these beautiful creations of the potter's art—who are surrounded by the tangible evidences of its loveliness—probably rarely, if ever, bestow a thought as to how they are produced. It is also probable that there are not very many who know much about Minton's establishment, what it is like, where it is situated, who established it, and how it has developed. Let us travel together for a short time to Stoke-on-Trent, and we shall then be able to learn something about this popular manufactory.

About a quarter of a mile from the railway-station there is, in the heart of Stoke-on-Trent, a thoroughfare called High Street. It is a long and undulating street, rising at one end to a steep hill, beyond which may be discerned, through smoking kiln and stack, the faint outline of trees, and a few green fields. In the centre of this thoroughfare, at the foot of the hilly descent, there stands before you London Road, and also Minton's works. And what an establishment it is! For a distance of about 280 yards it runs on both sides of this road. Externally, it is a solid block of brick buildings, substantially built, looking somewhat dark and sombre from atmospherical causes; but with a certain aspect of importance which sometimes is indefinably conveyed to the mind by even bricks and mortar. On the right-hand side of the road, looking from Stoke-on-Trent, is the department devoted to the manufacture of earthenware; whilst opposite is the china section of this vast porcelain manufactory. The spirit of progress is manifested everywhere in this place. It has been built, enlarged, and altered time after time, in order to facilitate the enormous trade which is done, and to administer to the comfort and health of the work-people. This progressiveness is not confined merely to the extension of working area; but shows itself in the application of the latest improved machinery and scientific discovery. For instance, there is telephonic communication from one department to the other, so that messages may be conveyed with rapidity, and without much physical effort.

Minton's works have not been established a hundred years. As a matter of fact they were founded in 1793, by Thomas Minton, of Caughley, Salop. He came to Stoke as a simple engraver, in 1788; and when he died on May 29th, 1836, he had set his mark, to be perpetuated by his successors in a singularly successful manner, on the fascinating industry of pottery. Before his death he saw the first production of encaustic tiles as an English industry; and some of these tiles made at Minton's were laid on the floors of our House of Commons, and were trodden by great statesmen, and impassioned orators, long since dead. Thomas Minton was succeeded by his son, Herbert Minton. This gentleman took into partnership Mr. Michael Daintry Hollins and his nephew Colin Minton Campbell. The fame of Minton's ware had all this time been increasing, and in a corresponding ratio their business flourished. Herbert Minton died in 1858, but not before he had seen the manufacture of majolica started in 1850, and carried to a very successful trade issue. When Herbert Minton died, Mr Michael Daintry Hollins and Colin Minton Campbell conducted the business until 1868, when there was another change in the constitution of the firm. There was a dissolution of partnership; and Mr. Campbell was joined by Mr. Thomas William Minton and Mr. Herbert Minton.

It will easily be understood that the superintendence of a great concern like this demands

special care and, one might almost say, special capacity; and it must certainly be admitted that this large establishment is well administered. The area of Minton's china works is twelve acres. Including Mr. Campbell's brick and tile works, which closely adjoin the other manufactory, they give employment to two thousand persons. In the printing process alone there are more than a hundred persons engaged; and there are about forty artists—exquisite painters—under the leadership of M. Léon Arnoux, the "art director" of the establishment, a gentleman of varied accomplishments, a ripe scholar, with a knowledge of science, art, and practical pottery, which has deservedly gained for him the highest and the most distinguished position in connection with ceramic manufacture. The responsibility which rests upon Mr. George Leason, manager of the manufacturing department, is no light or easy one; for to discharge it successfully, as he does, means to keep in continuous and perfect order the large industrial forces under his control. Mr. Leason is a thorough potter; and through his skill, penetration, and ability knows in its minutest details every branch of the industry. In a previous chapter we spoke of the skill required for mixing the colours in an ordinary pottery manufactory. What exceptional ability this requires at a place like Minton's need not be even indicated. Mr. Herbert Minton, who performs this work, knows from a wide and varied experience, exactly the varying and beautiful shades which, after firing, the colours will assume. Of the great quantity of china which is constantly manufactured at Messrs. Minton's, some idea may be formed when it is stated that there are seventy-six kilns and ovens. The consumption of coal for heating these kilns is as much as one hundred tons per day.

IRON AND STEEL.—XXV.

CUTLERY: SECOND PAPER—SHEFFIELD PRODUCTIONS.

By Charles Hibbs.

We have mentioned the fact that Sheffield, which is now fitly called the metropolis of steel, did not begin to manufacture steel for herself till a comparatively late period in her industrial history. But her dependence on foreign supplies by no means ceased at that time, for it would be difficult to say what would have become of her industry, either then or since, without *Swedish iron.* This beautiful and hitherto indispensable material is derived from a single mine, that of Dannemora, which is said to have been worked for nearly 400 years, and does not yet show any signs of exhaustion. When first cast into "*pig*," this iron is as white as silver and as brittle as glass, but it becomes remarkably tough and fibrous when reduced to the malleable state by being heated with charcoal and repeatedly hammered. The whole produce of this mine used to be consigned to a single mercantile house in England, and perhaps nine-tenths of it found its way to Sheffield, there to be converted into the very best of its world-famous steel. Nothing is more familiarly known to the Sheffielders than the old trade-mark—"Hoop L" (a circle enclosing the letter thus Ⓛ)—of this remarkable iron. Metallurgists have been divided in opinion regarding the cause of its superiority. Some have supposed that it consisted in the presence of manganese; if that be so, the modern method of adding manganese to cast steel in the process of fusion may some day enable the Sheffield steel-converter to produce equal results with English iron.

The various stages of conversion need be no further alluded to here than is necessary to illustrate the peculiar character of Sheffield trade-life. Division of labour seems the most marked feature in this initial department, as in the later ones of finished cutlery manufacture. One house will confine itself to the first process of converting iron into steel by cementation.* Another will be devoted entirely to the process oddly known as *shearing* (see previous chapter), which consists of faggoting the pieces of blister or crude steel together, and hammering them with steam or *tilt* hammers, from which the establishment itself, naturally enough in Sheffield *parlance*, comes to be called a "Tilt." In old maps of the town we may see such places marked down as "*Mr. ——'s Tilt.*" Others, again, restrict themselves to the production of *cast* steel, or to the making of crucibles for the same; the tilting of cast steel being also in some few cases a

* For a description of this process, see Vol. I., pp. 276, 278.

special industry. There are some large establishments where all these departments are carried on together, but the genius of Sheffield trade still favours their separation. As pot-making and steel-casting are among the most prominent sights in Sheffield, we must pause to describe them a little. It is not a pleasant occupation, especially in wintry weather, to tread out wet clay with naked feet for several hours at a time, yet this is the principal duty of the labourers in a crucible house. No other method of mixing or working up the clay has been found to answer the purpose so well as this kneading with the human foot. A layer of the paste (Stourbridge clay well mixed with water) is spread out on the floor of the shop, within shallow ledges which keep it in bounds, and the treaders—one or more, according to the space—trample, stamp, and dance upon it till every inch has been thoroughly pressed and squeezed many times, and all the air-bubbles are supposed to be expelled. The moulder takes a lump of this well-tempered clay, and with a few motions, by the aid of an iron mortar-shaped vessel and plug, fashions it into a crucible, about 2 feet high and about 26 lbs. in weight. A number of these are dried together in a kind of vault, and are then stored for use. But immediately before using they require to be further prepared for the fierce heat they have to undergo, and they each pass a night under a covering of warm ashes on an annealing grate. The slightest flaw or crack would, of course, condemn them to ignominious breaking-up, but the best and soundest will only bear one day's work in the melting furnace. Before the introduction of the Bessemer process, it was supposed that the heat of a steel-melting furnace was the highest known in the metallic arts; and even to one who has witnessed that tremendous eruption of incandescence, the blinding, scorching glow of the old furnace-hole is something fearsome. The spectator may well wonder that the human frame is capable of withstanding such intense heat, which seems sufficient to shrivel up everything within its reach; yet the workmen, scarcely troubling themselves with any precautions, lift the pots white hot from their fiery beds, and pour their boiling contents—which a stranger could no more look on steadily than he could stare at the sun—into the mould prepared for them, without any apparent injury or even difficulty. Four workmen take part in the operation, each having his allotted work. The first lifts with a long pair of pincers the pot from the furnace; the second strikes off the adhering cinders, &c., with an iron bar; the third grasps the crucible horizontally with another instrument, and conveys it, with the assistance of the first man, to the mouth of the ingot mould; the fourth stands by to clear the liquid of any impurities as the third pours it. A profusion of light green sparks, dazzling as the electric light, accompanies the pouring. The severe manual labour involved may be estimated from the fact that an ingot may weigh from 30 to 200 pounds. In the Exhibition of 1851 there was a monster ingot, weighing upwards of 2,688 pounds, from the works of Mr. Turton, the then Mayor of Sheffield. The pouring of this must have been a sight never to be forgotten.

Cast steel ingots may be either tilted or rolled, according to the purpose for which they are required. If the first, they are now usually submitted to the steam hammer, after the manner described in Vol. I., p. 279. The old-fashioned "tilt," however, is still a surviving institution of Sheffield, and may be seen and heard in the neighbourhood of one or other of the rivers, its ponderous water-wheel revolving lazily in the stream. Here the incessant thump, thump, thump of the hammers, such as we might imagine to have been wielded by the giant Thor, at once deafen the ear and shake the frame by their concussion. By such means the ingots are drawn down into bars of varying length and shape, and the steel acquires new properties, such as toughness and closeness of grain, by being so treated. If sheet steel is required, for saw-making or other purposes, the ingot is rolled out under ponderous rolls, in the same manner as we have previously described sheet iron to be, but with concomitants of much greater heat and nicety of manipulation.

It is after this point that the many branches of cutlery manufacture proper begin to come into play. So far we have been concerned only with the raw material of that manufacture. A glance at a Sheffield Directory will inform us how many and how various those branches are, and what a vast and curiously inter-connected system supplies us with the implements we require at every turn of our daily lives. Man has been defined as a tool-using animal; and if this were the sole distinction between him and the brute creation, the very source and fountain-head of his development would be found in Sheffield. Existing as complete and separate trades, besides the preliminary ones of steel-converters, crucible-makers, casters, tilters, and rollers, we find table-knife-makers, fork-makers, penknife-makers, lancet-makers,

razor-makers, scythe-makers, saw-makers, edge-tool-makers, scissor-makers, shear-makers, spade and shovel-makers, and many others; and, in addition to these, the subsidiary occupations connected with the making of handles, such as dealers in ivory, tortoise-shell, pearl, horn, or bone, ivory cutters, bone pressers, horn pressers, &c. &c., together with those trades which supply the appliances of implement manufacture, and the marks and ornaments with which they are adorned. We have said that the location of steel manufacture in Sheffield has led to the establishment there of many industries which are outside of our present inquiry; in like manner the concentration of such merchandise as horn and bone has caused comb-making and other like manufactures to be also staples of the place.

Table cutlery, as coming nearest to man, when considered under another of his definitions as a dinner-loving animal, shall take the *premier pas* in our description. A table-knife, too, is a good representative instrument, the various stages of its production resembling closely those of other articles of more coarse or more delicate make, with certain differences of detail. But, as will occur to every one, there is a vast difference in quality between one knife and another. Some of the lowest-priced knives have had little experience of the refiner's furnace, and may be even in the unconverted state of natural iron. Ordinary qualities are made of common steel; better qualities of half-shear, shear, or double-shear; and the best of cast steel. Bars of all these qualities, and of a size specially produced for knife-forging, are procurable at the steel merchant's. The cutler's smithy does not differ from an ordinary blacksmith's, except in the size of the anvil and other appliances, which are much smaller. Neither does the operation of forging a knife-blade differ from blacksmith's work in any other particular than its being generally a lighter kind of labour. The blade only of the knife is made of steel; the tang, or part to which the handle is to be affixed, is made of iron. Therefore, the workman, when the blade is near completion, welds on to the butt end of it a piece of square rod iron, which he draws down to the required form for the tang. If this is to be inserted in a solid handle, he draws it into the rudimentary form of a spike; if the handle has to be riveted upon it in two parts, then he has to hammer it into the resemblance of a shorter blade. The bolster, or swelling part between the blade and the handle, is formed finally by a process which combines the operations of forging and stamping, and which is known in the trade as a "swage." A final heating and hammering give the now completed knife its proper contour from end to end. Hardening and tempering are effected when the forger has a number of blades ready for the process. He gets a good even fire, and taking up one blade at a time with his pincers, holds it in the glow till it is a "worm" red, or cherry red, all over; he then plunges it, quickly and perpendicularly, into a vessel of cold water, afterwards passing it over the fire till it is re-heated sufficiently to reduce its brittle hardness to the proper temper, or degree of elasticity.

Steel forks are not now used in connection with best table cutlery, so it happens that none are made except of the commoner kinds. The very commonest are simply cast iron, of the kind known as "malleable," *i.e.*, iron softened after casting by a peculiar process of annealing. The best are made of common steel all of a piece, for it would not pay to attach to them a tang of iron. The shape is first roughly attained by forging, and completed by swages and dies; and, as regards the prong part, by a blow of a heavy stamp. This last forms the "tines" completely, leaving only a thin web of metal between, and this is cut out afterwards by a fly-press. The forks are then softened a little, to allow of being dressed up with a file and afterwards hardened in the same manner as knives. Both articles are now ready for the "wheel."

The wheel, as we have previously explained, is the Sheffield name for a grinding-mill. At a large establishment of this kind all sorts of grinding may be going on at one time—saw-grinding, file-grinding, scissor-grinding, and knife-grinding — the heavier work on the ground floor, and the lighter in the rooms upstairs. The stones vary in size from seven or eight feet in diameter to less than that number of inches, and are also of varying degrees of texture, or "grit." Those used for grinding table-knives are about four feet in diameter, and revolve at great speed, being constantly sluiced with water to prevent the blade from getting heated. We may remark in passing that this is one of the chief points to be attended to in grinding —care that the article shall not get heated, and lose its temper. The knife-grinder completes what the forger has begun, viz., the nice and regular tapering of the blade from back to edge, and from heel to point, and when he has done this on a rough stone, he puts a finer surface on the article by grinding on a stone of closer grain. Much care requires to be exercised in the selection of these

stones, and on the keeping them in order. A stone, for instance, allowed to stand long partly immersed in the water-trough would become soft at that part, and would soon lose its true rotundity; in which case it would require to be "razed," or turned true with sharp instruments. Some stones have to be hacked at short intervals across their width to enable them to cut. There is a passage in Rabelais which refers to this:—"As, for example, we do sometimes see cutlers with hammers maul their finest whetstones, therewith to sharpen their iron tools the better." Great circumspection is also necessary to guard against using a stone with the slightest flaw or fracture, as the consequences of a stone "flying" while at work are sure to be most serious. Without any warning it may split asunder and crush the grinder to a jelly, or knock down the walls and lay the building in ruins. On one occasion we were shown a huge fragment of a grindstone deeply embedded in the earth, which had burst through the roof of the grinding-shed, and performed a flight through the air across the whole width of the yard. But accidents like these are not, unfortunately, the only perils which beset the poor grinder. The constrained position in which he works, the cold, muddy slop which saturates his clothing, the grit and moisture which he continually inhales, all tend to undermine his health and shorten his life.

Unhealthy as this occupation is, that of the fork-grinder is ten times worse. For some reason or other, he is compelled to use a dry stone of hard, close grit, and the fine particles, mingled with steel-dust, which are emitted in profusion during the whole time he is bending over his work, find their way to his lungs with every breath he draws, and produce an asthmatic disease, which is known by the terrible name of the "grinder's rot." A high medical authority of Sheffield has declared that most of the workmen in this branch "perish miserably" before forty years of age. It is satisfactory to know that mechanical precautions against this fearful evil are coming more and more into use, but for many years there was a stolid prejudice against them on the part of the victims themselves, who not only disliked the trouble they involved, but actually preferred the certainty of broken constitutions and speedy death to the risk of having their trade overrun, and the possibility of lowered wages.

After being ground, both knives and forks are polished upon emery "bobs," and sometimes glazed, or "lapped," on a metal wheel, consisting of an alloy of lead and tin. Of course, quality is shown in the perfection of polish as well as in selection of material, especially as the best steel is capable of bearing the highest polish. They are now ready for "handling," and here we leave them for the time, to follow the career of some other articles up to the same stage.

Pen and pocket knives employ an entirely different set of workmen; and even in this set there will be some sub-divisions. There are many varieties in this branch of cutlery—more than would be suspected by the uninitiated. To begin with, there are single-ended and double-ended knives, the designations of which speak for themselves; then there are sunk-jointed, sportsman-lock, sheep-foots, slotts, take-outs, snecks, and many others, whose meaning is not so obvious. Sometimes the pocket-knife maker exults in producing a *multum in parvo*, or instrument which contains the greatest possible number of articles wanted for minor emergencies, such as tweezers, corkscrews, &c. A knife was shown in the Vienna Exhibition which contained no less than 100 different articles. These are the knives which are technically known as take-outs. The staple is, of course, the ordinary penknife, spring-backed, with two or three blades, generally double-ended, and having a thin plate of separation down the middle, or not, according to quality. It is really a dainty operation to witness the forging of a tiny pen-blade—the tools used have such a *bijou* character when compared with those of ordinary blacksmith's work. A few blows suffice to get the first rough shape of the article from the heated end of a thin bar of steel; it is then cut off, held in a pair of pincers, and the butt fashioned into the rude semblance of a joint; and a third hammering completes its form almost perfectly, leaving little for the grinder to do. At this stage the nail-hole is struck in with a chisel. The blade is only hardened up to the head: that part being left soft for drilling. As a penknife-blade forger is called a pen-forger, for short, so a grinder of the same article is called a pen-grinder; such being according to the Sheffield custom of abbreviation. The operation of grinding it is not necessary to describe. Razor and surgical instrument forgers and grinders consider themselves among the *élite* of the trade, and with justice, for their work is characterised by great nicety. The blade of a good razor must be made of the finest steel; it must be hammered with reference to its temper as well as to its shape, and it must be ground with the same view. It is always more or

less concave from back to edge, and learned treatises have been written on the proper degree of concavity which it should bear. The great difference in substance between back and edge also presents a difficulty as regards the tempering of the article. For the purpose of obtaining greater certainty in this respect, these finer wares are sometimes tempered after they are brightened, the degree of temper being more easily ascertainable by watching the changing colour of the metal while undergoing heat. The formula of the trade is :—pale straw-colour for razors, yellow or orange for penknives, purple for scissors, and bright blue for springs; but these may be modified according to the texture of the steel or the experience of the workman. The great thing in this, as in all other branches of cutlery, is to produce an instrument of the best "cuttynge edge," and one that will suit the particular kind of cutting which it has to do.

We now come to deal with the "handling" of these various classes of goods, an operation which has sufficient similarity to justify us in grouping them together, but which in practice is subject to the same sub-division of employments as we have so many times remarked. A *table-hafter* differs radically from a *pen-mounter*, and a razor-handler differs from both. Here we must explain that handles which are in one piece are called *hafts*, whereas those which are in two halves are called *scales*. Table-knives may be mounted in both ways. In the first the tang is inserted in a hole drilled in the haft, and is there fixed by a kind of cement; in the second the two sides are riveted on. Housewives know from painful experience how insecure both these methods of attachment often prove to be; and it is a sort of reflection on Sheffield ingenuity that no firmer system of fastening has been yet devised for common use. Haft and scale makers form, of course, a separate trade, or it may be said many separate trades; and great is the variety of substances with which they deal. Some work specially in mother-of-pearl, others in ivory or bone, others in ebony and other hard woods, and others in horn, which, again, has two sub-divisions—natural or stag's horn, and pressed or moulded bullock's horn. These materials are cut or moulded into sizes and shapes universally known in the trade, and distinguished by numbers or names; so that the mounter has little to do but to put the pieces together. The pen-mounter has the most complicated task to perform, in adjusting the many parts which go to an ordinary penknife. There are the blades; the back, which also forms the spring; the metal sides or scales, which really constitute the handle of the knife—the outer scale of pearl, tortoise-shell, or what not, being mostly for ornament and finish; and lastly, the studs, shields, and metal bosses which decorate the exterior. His duty is to *assemble* all these, and perform such fitting and connection as may be necessary, riveting all neatly together, and polishing off as he goes on, till the knife not only looks well, but will act and speak well; till, in the language of the trade, it will "*walk and talk*." As Mr. George Dodd remarks, "the mounter does to a penknife what a watch-maker does to a watch: he makes very few of the parts, but he adjusts them all."

Scissor-making, in all its branches, forms one of the most important industries of Sheffield, and employs not the least skilful of its workmen. The operation of scissor-forging is more curious to witness than many others, as the somewhat involuted form of these articles may well testify. The forger uses an anvil of rather peculiar shape, having a number of contrivances called bosses, which are indented with the patterns required for various parts of the scissor-shank, after the manner of dies. He forms the shank first, beating it out a little at the end, and punching a small hole, as the first step towards making the bow. He then cuts off the piece from the bar, leaving himself a little length of steel wherewith to form the blade. This is next fashioned, and is a comparatively straightforward piece of work; the remaining portion is the most difficult. He heats the perforated end of the shank again, and draws the metal out by hammering on a peg or horn of the anvil till it assumes the form and dimensions of a bow, the finishing touch being accomplished by means of the bosses. From a number of such forgings the scissors are paired, and filed to greater regularity; they are dressed also by filing in all those parts which the grindstone cannot reach. Each scissor, if we may so express it, has to undergo two processes of grinding: one on a large stone for the outside of the blade, and one on a small stone for the inner face—that, like the razor, being all the better for having a slight concavity. In polishing, a revolving hard brush, treated with proper material, is used for all the intricate parts. The peculiar form of the scissor-bow seemed to lend itself to the processes of stamping; but such is the dexterity of the forgers that hitherto their art has not been seriously interfered with. Many common scissors are, however, produced by casting, a method which leaves no room for the stamping process. It need scarcely be said that these

scissors are made to sell; they can hardly be made for use. Even that part of their mission they scarcely accomplish, for many are disposed of for less than a farthing a pair. As a contrast to these we may refer to the artistic productions in "fine filing" which are sometimes contributed to exhibitions. There was a pair shown at Vienna by a Sheffield firm which had the royal arms filed out of the shank; others, showing scroll work and various forms of ornamental design, have been often illustrated in our art publications. Inlaid, damascened, and otherwise enriched work of a high character may be seen in many a show-case in Sheffield, showing that there is no lack of taste among her somewhat rugged population.

We must not dwell upon the larger members of the scissor family, such as tailor's shears, wool-shears, garden-shears, &c.; nor must we do much more than enumerate the principal remaining staples of the great cutlery metropolis. It will suffice to say that Sheffield has long had a monopoly of the wool-shear trade; and as regards other implements used in agriculture, no rival has yet been able to oust her from the field. Scythes, sickles, pruning and hedging knives, blades for chaff-cutting and other machines—in short, all cutting implements used for the garden or the field—are supplied from Sheffield to almost every part of the globe which is under cultivation. America runs us hardest in that race; but the Sheffielders say they can always depend upon a market for their more substantial, if heavier, work. In joiners' and edge tools generally, they maintain that no nation has ever yet been able to touch them. Every workman knows the value of a good tool; and workers in wood especially know what a pleasure it is to work with a whole "kit" of tools of equable quality, temper, and *cut*. A gun-stock maker who does best work will sometimes spend years in making a selection of chisels for cutting away the delicate parts of the lock, and when he has got a set to his mind he will be as careful and as proud of them as a surgeon of a case of instruments; but he never thinks of trying any that are not Sheffield make. Files and rasps, too, of which such enormous quantities are used in the hardware trades, are almost universally preferred with the Sheffield brand; although many are made and sold in Birmingham, Wolverhampton, and other hardware centres. It is convenient to deal with a local file-maker, especially where there is a large consumption, because of the re-cutting; but still, most workmen hold the belief that Sheffield files cut the best and last the longest.

Saws, again, of all kinds, from the monster "circular" to the tiny "fret," will be found in ninety-nine cases out of a hundred to bear some well-known Sheffield maker's name. And even in those cases where we see an occasional manufactory of Sheffield staples located in such towns as Manchester or Birmingham, we can scarcely call it competition; for the material used in nine cases out of ten will be Sheffield steel, and the workmen Sheffield workmen. London has a reputation for fine cutlery, as for many other branches of high-class manufacture, and the general explanation of this will be that the best of everything is naturally attracted to the capital. But it has been stated that 99 per cent. of London cutlery is actually made in Sheffield; and, no doubt, the remainder is produced by men chosen from the pick of the Sheffield labour-market.

As regards foreign competition, the mind of the typical Sheffield artisan is strongly imbued and fortified with the notion that it never can touch him seriously. He admits that the low-priced labour of France, Belgium, and Germany will enable those countries to undersell him in the very commonest wares, but he cares little for that; he contends that the business of a cutting instrument is to cut, and if that is what is wanted people must come to *him*. It takes a great deal to disturb his equanimity on this subject. When the Artisan Reporter on Cutlery for the French Exhibition of 1867 (Mr. John Wilson) made his report to the Society of Arts, he pointed out very fairly that the Continental productions showed generally a great advance since the Exhibitions of 1862 and 1851; but with reference to that fact he makes the following complacent remark:—"If the progress made by other countries seems greater than our own, it is because in the manufacture of cutlery we are much nearer perfection; and therefore it is impossible that our progress should be as marked as those emerging from a rude state of manufacturing." The Sheffield forger knows also that a good deal of his work is sent abroad as "job-blades," and he argues that if the foreigners could make good blades for themselves they would not want his. It also occasionally comes to light that finished goods are transported bodily to foreign houses, to be exhibited and sold as of Continental make; and about this Mr. John Wilson, who was also accredited to the Vienna Exhibition, had a curious tale to tell. He was examining a case of German goods there, and the exhibitor challenged him to produce any Sheffield razors equal to those he was showing. Mr. Wilson was not then in a condition to comply; but after his return home

he writes :—" Now circumstances are different, and I can produce the man who ground them, and the manufacturer who made them, with the Sheffield merchant through whom they were supplied." As a confirmation of this statement, he sent in his card, impressed by his own hand, in Sheffield, with the very mark which had stamped the goods with the German manufacturer's name. On the whole, while viewing the present position of the trade in all its aspects, we have no reason to doubt that the proud pre-eminence of the ancient home of cutlery is well maintained.

MODEL ESTABLISHMENTS.—VIII.

THE SINGER MANUFACTURING COMPANY'S FACTORY AT KILBOWIE, NEAR GLASGOW—SINGER'S SEWING MACHINES.

By David Bremner, Author of "The Industries of Scotland."

TOWARDS the close of last century, a time remarkable for the production of those grand mechanical inventions which revolutionised the textile manufactures of the world, some attention was given to the discovery of means whereby the tedious process of hand-sewing might be superseded. The problem was difficult, and most of those who attempted its solution relinquished the task as a hopeless one. In the year 1790, however, Mr. Thomas Saint patented a mechanical sewer, in which were embodied some of the essential features of the most approved sewing-machines of our day. In the course of the next few years Saint's idea was improved upon, and some entirely novel machines were produced. But somehow these inventions failed to be appreciated; and fifty years after the date of Saint's patent the sewing-machine had not achieved a much higher rank than that of a mechanical curiosity. Its day was at hand, however, and when appreciation came it came with a rush. A set of inventive minds concentrated themselves on the machine simultaneously, and it was, so to speak, hurried to perfection. It would be interesting to relate the story of the development of the machine into its now well-known forms, and to describe the nature and extent of the industrial revolution which it has brought about; but we must resist the temptation to deal with these topics, and confine ourselves to giving a brief account of one of the most conspicuous and successful of the mechanicians who contributed to the perfecting and popularising of the sewing-machine, and a description of one of the "model establishments" which owe their existence to his ingenuity and enterprise.

Mr. I. M. Singer was born on the 27th of October, 1811, in a small village in the State of New York. His father was a working millwright, and consequently was not in a position to give his son a high education, nor to avert from him the common lot of his class—the earning of his bread by the sweat of his brow. Young Singer showed great aptitude for mechanical work; but does not seem to have achieved anything remarkable until after he had passed middle life. In the year 1850, we are told, his attention was attracted by a newly-invented machine for sewing. After examining it with a critical eye, he told some of his friends that he had conceived certain ideas on the subject which he felt confident would enable him to produce a better machine at half the cost. He set to work immediately, and, sure enough, in less than a fortnight he gave practical illustration of his conception, by submitting to inspection a machine which was generally recognised as being superior in several points to any previously produced. He seemed himself to be fully conscious of the value of his invention, and, after securing it by patents, he sought means for manufacturing it and introducing it to public notice. His improvements related to several important details of the machine more than to any decidedly original principle of its action. Previous inventors had introduced the then leading features of all machines — the continuous thread, the eye-pointed needle, and the continuous feed; but they had not succeeded in getting them to work in anything like a satisfactory manner. By close study Mr. Singer detected the weak points, and by a series of most ingenious modifications brought them to work in complete harmony.

Mr. Singer's first American patent for "improvements in sewing mechanism" was obtained early in the year 1851, and from that time till shortly before his death, which occurred in 1875, his name frequently appeared on the patent lists of both this country and America. At first his attention was chiefly devoted to what are known as "needle and shuttle machines," and he made it

especially an object to simplify the complicated and somewhat clumsy details of the earlier productions, reducing the number of their working parts one by one, and so improving the mechanism that he ultimately produced a series of lock-stitch machines for every kind of sewing, which have never been surpassed for the beauty and durability of the work they perform. In 1854 he obtained a patent in America for a double-thread chain-stitch machine, and another for a single-thread chain-stitch machine, both of which obtained a high degree of popularity. Having once fairly launched into the field of invention, the fertile brain of Mr. Singer seemed to know no rest. He was ambitious to produce machines capable of doing every kind of sewing and embroidery; and one after another, in quick succession, he contrived a series of improvements, having for their objects hemming, felling, tucking, quilting, cording, embroidering, boot-flowering, &c., most of which have been generally adopted as the best of their kind. In 1855 he patented an embroidering machine, with a vibrating needle carrying a thread to interlace with other threads, and so producing the stitch which is the foundation of all embroidering machines subsequently invented. Among other products of his genius were machines to make two rows of stitches simultaneously, and to form long and short stitches alternately. One important invention connected with sewing machines he did not patent. That was the double-action pedal now in universal use in foot-driven machines.

But Mr. Singer, though devoting special attention to sewing mechanism, did not confine himself to that field of invention. As illustrations of his versatility, we may mention that he was the author of improvements in the construction of steam-engines, paddle-wheels, carriages, and harness. He also patented a cinder and ash receptacle, and a new form of shirt. In many departments of manufacturing industry he left traces of his hand. While developing the manufacture of sewing-machines he was hampered at some points by the patents of prior inventors, and this at one time or another led to costly litigation. Owing to restrictions of this kind, he was not allowed to sell certain makes of his machines in England till the year 1860. Prior to that time he had assumed a partner, and business was carried on under the designation of "I. M. Singer & Co." It was determined in 1863 to extend the operations of the firm considerably, and with that view some of the leading employés were taken into the partnership, and the designation was changed to "The Singer Manufacturing Company." Singer's machines were becoming known everywhere, and the demands on the productive powers of the factory increased at a rapid rate. Some time after the company had been formed Mr. Singer went to Paris to live, and remained there until the outbreak of the Franco-German War, when he removed to England. His health was then failing, and he died, as already stated, in the year 1875, at his residence at Paignton, Devonshire.

Finding that the demand for Singer's sewing-machines had attained a point in Britain, and various continental countries, to warrant such a step, Mr. George R. McKenzie, then General Manager, now President of the Company, recommended the establishment of a factory at Glasgow to meet the requirements of this section of the Company's trade. The idea—a very happy one, as the result has shown—was promptly adopted and acted upon. Premises were hired, and, in 1867, a start was made on a modest scale. At first most of the parts of the machines turned out at the Glasgow factory were obtained from America; but in the course of three years the demand on the resources at head-quarters was so great that it was determined to extend the Glasgow works, and adapt them to the manufacture of every part of the machines. Provision was made at the outset for the production of 600 machines per week. Ten years later the Glasgow factory had assumed gigantic dimensions, occupying several very large buildings, and turning out 5,000 machines every week.

But the limit of expansion was not yet reached; and the question arose whether the time had not come for the erection of a new factory on a grand scale, in which all the scattered departments would be concentrated, and provision made for meeting any future increase of business. The question having been answered in the affirmative, a site for the new works was chosen at Kilbowie, on the north bank of the Clyde, about nine miles from Glasgow. The plot of land acquired measures forty-six acres, and on this has been erected the largest manufactory of its kind in the world. Along one side of the works is the Forth and Clyde Canal, and along the other side runs a branch of the North British Railway, so that the facilities for transport leave nothing to be desired. The engraving on page 229 gives a good general view of the establishment. The total floorage area of the buildings is twenty-two acres, and the

various departments are so arranged that the iron, steel, and wood used in the construction of the sewing-machines pass through process after process with the least possible amount of handling.

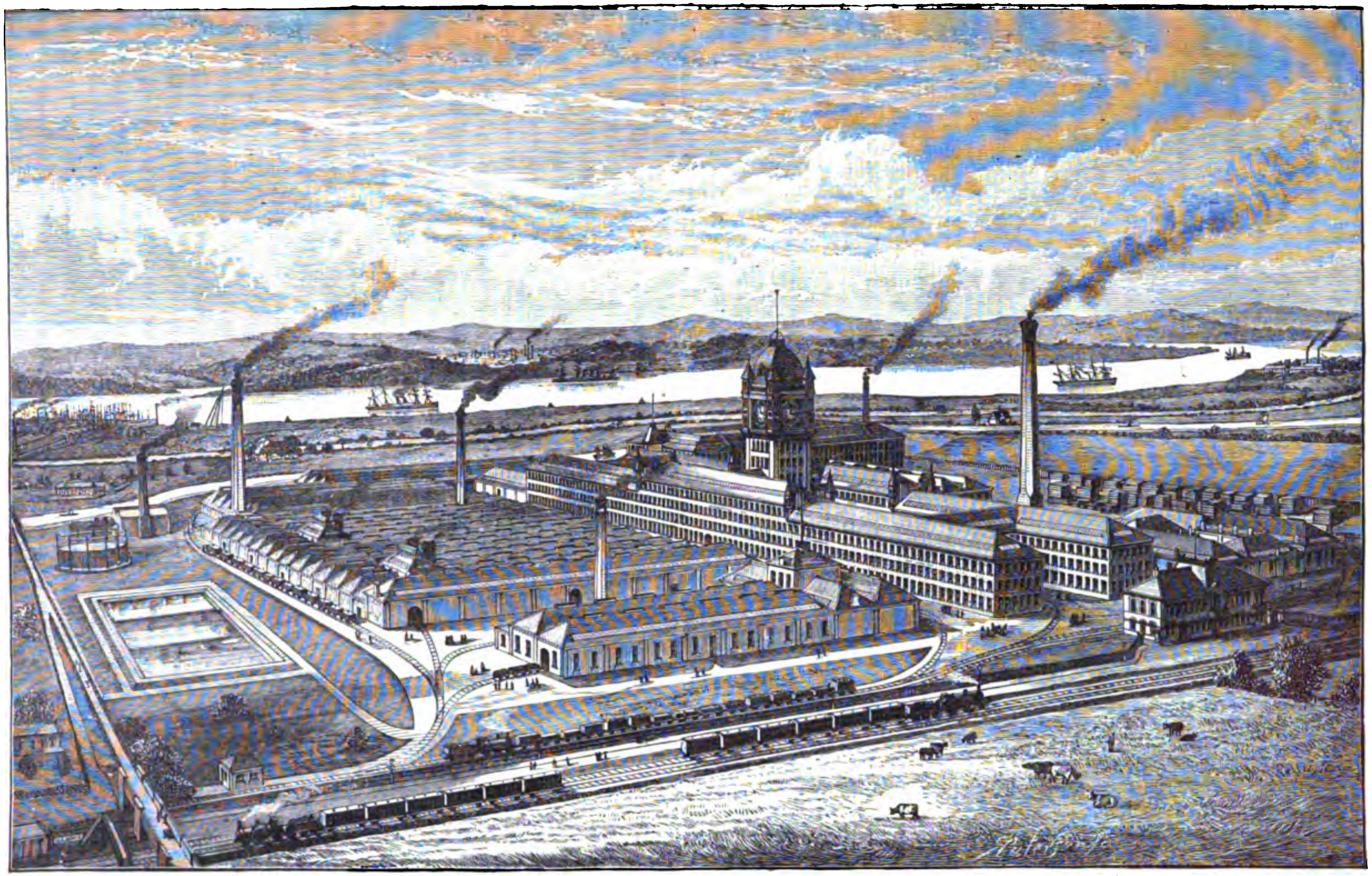
The factory comprises the following buildings :— The foundry, a one-storey block measuring 448 feet in length and 352 feet in width; the rumbling department, one storey, 352 feet by 62 feet; the dressing department, one storey, 288 feet by 31 feet; the stand drilling and ornamenting shops, one storey, 228 feet by 192 feet; the manufacturing department, consisting of two main buildings, each 800 feet long and 50 feet wide, four storeys high in the central portion and three storeys at the ends, and connected at three points by transverse buildings of corresponding height; the forge, which has an area of 26,560 square feet; the machine japanning department, 276 feet by 102 feet; the packing department, 155 feet by 48 feet; the cabinet and box-making factory, with a floor area of 159,661 feet; the main boiler house, 110 feet long by 50 feet wide; the storage and shipping department, 384 feet by 128 feet; the boiler-making shops, 308 feet by 98 feet; the oil store, 120 feet by 25 feet; the general offices, 110 feet by 30 feet; and the gas-works, 175 feet by 18 feet and 35 feet. Occupying a position in the centre of the two main buildings of the manufacturing department is a grand clock tower, 200 feet high and 50 feet square, in the Scottish baronial style of architecture. The clock-face is 25 feet in diameter, or three feet more than the face of the clock of the Houses of Parliament. All parts of the works are connected by a railway, having a total length of two and a half miles. The main buildings are constructed on fire-proof principles, and every provision that experience could suggest for the safety and comfort of the workpeople has been made.

The visitor to the works, on alighting at Kilbowie Railway Station, will first find his way to the general offices, which occupy a position in front of the main buildings. Obtaining a guide here, he will next proceed to the foundry, where he will at once receive a very distinct impression of the extensive nature of the business of The Singer Manufacturing Company. The foundry is one vast apartment with its many-sectioned roof supported on a forest of iron columns. The floor is divided into sections by lines of rails, on which the trucks carrying the great pots of molten metal to the moulds are run, and overhead are travelling cranes for moving heavy work. Occupying convenient positions at one side of the foundry are the cupolas, four in number, and capable of melting 180 tons of metal per day. Behind the cupolas are the metal stores, with a line of railway running through them, and here also are the hydraulic lifts by which the charges for the cupolas are raised to the charging platforms. For driving the blowers of the cupolas there is a fine steam-engine of 100 horse-power, for the general work of the foundry an engine of 250 horse-power, and for working the hydraulic pumps a pair of engines of 30 horse-power.

There are 700 men employed in the foundry, and when work is in full swing the place presents a very busy and interesting scene. No fewer than twenty-five separate castings are required for each sewing-machine, and these are of various sizes and shapes. The moulds for the castings are made in sand of the ordinary kind; but various special appliances are in use for facilitating labour and economising plant. For instance, in taking an impression of a bed-plate—that is, the flat plate which forms the foundation of the working part of a sewing-machine—a lever-press somewhat akin to a printing-press is used, and with its aid a mould is obtained in a fraction of the time needed to produce it by hand. There are nearly a hundred of these presses in the foundry. While the moulds are being prepared the cupola men are at their posts, and in due time the metal attains a sufficient degree of fluidity to admit of being drawn off.

A large vessel lined with fire-clay, and mounted on a truck adapted to the rails already referred to, is now run up to one of the cupolas, the charge is tapped, and the metal flows in a stream of dazzling brilliancy into the carrier. When the vessel has received a sufficient charge it is drawn along to one or other section of the moulds which cover a large space of the floor. The moulders then approach with ladles of various sizes, and receive a supply of metal from the carrier, which they pour into the moulds. This work, which usually completes the labours of the day, goes on till all the moulds are filled.

When the foundry men resume work in the morning their first business is to break up the moulds and extract the castings. If any of the pieces be now examined it will be seen that they are rough in parts, and have a coating of sand adhering to their surfaces. To remove this roughness and sand, the pieces are subjected to an operation called "rumbling," the appliances for



The Singer Manufacturing Company's Factory at Kilbowie, near Glasgow.

which occupy a large room adjoining the foundry. The rumbling machines, of which there are 126 in use, consist of iron drums mounted horizontally, and furnished with gear for giving them a rotary motion. The drums are partly filled with small star-shaped pieces of cast-iron. Into each drum a number of castings are placed, and the opening having been secured, the belt is slipped on, and the drum spins round. The effect of the motion is to dash and rub the small pieces of iron against the castings, and thus beat off the sand, and render the surface smooth. The time required for this operation is from two to four hours, according to the size and form of the castings. When taken from the rumblers the pieces are quite smooth, and shine as if polished with black-lead. From the rumbling-room the pieces are passed to the dressing-shop, where any superfluous protuberances or other defects are dealt with by the grinders, who use emery wheels of suitable sections. The next process is annealing, by which the metal is rendered less brittle than when it leaves the mould. The annealing is accomplished by sealing the pieces up in cast-iron boxes with a certain proportion of charcoal, and subjecting them to heat in an oven. The castings for the stands of the sewing-machines are now drilled, japanned, ornamented, and passed into the stores, while the smaller parts are assorted, and kept in readiness for such operations as they have yet to undergo.

If the visitor will now step into the forge, he will see how the wrought-iron and steel portions of the machines are operated upon. A peep into the iron-store will afford an idea of the extent and variety of work carried on. Among the furnishings of the stores are cutting-rolls for ripping sheet-iron, and shears for cutting bars. The forge contains two large steam hammers, six horizontal trip hammers, and sixteen drop hammers, not to speak of hand hammers. As the trip hammers rain blows on the work at the rate of 200 per minute, the din they make may be imagined. The power-press department adjoining the forge contains presses for stamping out parts, straightening, and trimming articles after they have been roughly shaped in dies under the hammers. The machinery in the forge department is driven by a Corliss engine of 100 horse-power.

The expedition with which work is executed in the forge is well illustrated in the forging of a feed-lever. Withdrawing with a pair of tongs from his fire a piece of square rod iron about six inches in length and three-quarters of an inch in diameter, the workman places it on the anvil, and pressing a lever with his foot, brings the hammer into operation. As blows descend rapidly upon the iron, he moves it to and fro so as to distribute the position of the blows and bring the iron into the desired form. His first object is to retain a square piece at one end of the forging and draw the remainder of the iron out until it becomes about half an-inch in width by one-sixth of an inch in thickness, except a portion of about one inch at one end, which is retained at a thickness of fully one-third of an inch. Next, a double rectangular bend has to be made in the piece. For that the iron is laid on a curved portion of the anvil, and a couple of blows suffice to bring it to the required shape. The workman is guided as to dimensions by a gauge attached to the anvil. The forging of one piece occupies little over a minute. Such parts of the machines as are formed by stamping are operated upon by presses or hammers, the faces of which are furnished with dies of chilled iron. The pieces of metal, after being heated, are laid upon the die, and the hammer is brought down upon them with such force that one blow suffices to give them the desired shape.

When the pieces leave the hands of the forgers and stampers, they have to undergo a number of operations before they are ready to be put together. Their rough surfaces have to be smoothed and polished, and they have to be nicely adjusted, for the corresponding parts of each class of machine are designed to be interchangeable. To follow them through these processes it is necessary to accompany them to the milling and drilling departments. These are situated in the main buildings, and in them the visitor finds himself in a region of wonders. Room after room, and floor above floor are crowded with machines of most ingenious construction. Hand-labour is reduced to a minimum, and systems of wheels, drills, and cutters perform a succession of complicated operations with unfailing exactness. The planing machine is very little used, the more modern milling machine having superseded it for work of this kind. For the benefit of the uninitiated, it may be explained that the milling machine does its work by means of rotary cutters of highly tempered steel, having a section corresponding to the desired outline, and that it is capable of almost universal application. There are no fewer than 200 milling and drilling machines in operation in this department, and it is most interesting to observe how they execute the work submitted to

them. The attendants have merely to place the pieces to be milled or drilled in a certain position, and the machines act upon them in a manner which would seem to betoken the possession of a high degree of intelligence. Of this the machine which drills the holes in the bed-plates of the sewing-machines may be cited as an excellent example.

In each bed-plate there are twenty-one holes of various sizes, some going through the plate, and others only partly through, some of the latter being on one side of the plate and some on the other. To drill these holes separately would entail a considerable amount of labour and changing from one machine to another; but here we see a machine which deals with all the holes simultaneously. It consists of a vertical disc with three compartments on its rim. On either side of the disc drills of the required sizes are mounted. The attendant places a bed-plate in one of the recesses and starts the machine. The disc makes one-third of a revolution and stops. While the plate is thus held, a certain number of the drills advance automatically, perform this part of their work and retire. The disc now moves round another stage; the plate is brought opposite a second set of drills, and having been subjected to their action, is advanced to a third set, and thus the work is completed. As each plate is finished, it is removed from the disc and a fresh one is inserted; and so on, the drills acting upon three plates simultaneously.

A beautiful illustration of the advantages of the division of labour—if the work of a machine may be described as labour—is afforded by the production of the sewing-machine shuttle. This tiny implement, shaped like a boat, and carrying in its hold a spool charged with thread, requires for its completion no fewer than three hundred distinct operations. It is forged in steel of the finest quality, and after being brought somewhat into shape by stamping, milling, and drilling, its tip is shaped by one machine, its heel by another, and the bottom is rounded by a third until it is turned out complete with thread-holes and slits pierced, and bobbin-centres, spring, and thread-guide fixed. At a convenient stage of its progress, the tip and heel are specially tempered to harden them. The thread-guide is a scimitar-shaped piece of highly-tempered steel adjusted to the side of the shuttle. It is formed by punching from a ribbon of metal mounted on a reel, from which the punching machine feeds itself, as it clatters away at the rate of 250 strokes per minute.

The needle is another part of the sewing-machine whose production is likely to arrest the visitor's attention. To it the central part of the upper floors of the two principal buildings are devoted. If one of these needles be examined, it will be seen that it differs from the hand-sewing needle in several important respects: the point is more obtuse, and its eye is only a little distance above the point. The shank beyond this is grooved on two sides, and the upper part, which fits into the clamp at the end of the needle-bar, is of greater diameter than the lower. The needle-making machines are marvels of automatic mechanism, but it is hardly possible to write a description of them that would be intelligible to the general reader. Suffice it to say that they are supplied with coils of wire, from which they cut pieces of sufficient length to form needles, and that they successively straighten, mill, groove, and point these, and arrange them in a receiving box ready for the further operations of having the eyes punched, and so on. The pieces are passed from one operation to another in the machines by pairs of metallic fingers, whose motions are most interesting to witness. About two hundred workpeople are engaged in the needle department, and the average production is over 500,000 needles per week, a rate that will be increased to double that number.

Another department containing some wonderful machines is that in which the screws and pins used in putting the sewing-machines together are made. This occupies the whole of the second floor of one of the main buildings, and it is furnished with over a thousand machines and tools of a more or less complex character. The screws are all turned from mild steel bars without any preliminary forging. There are forty automatic screw-making machines at work. When these are to be started, each is furnished with a long rod of steel, and from this, by a succession of beautiful operations performed by a series of cutting tools mounted on a turret-head or monitor, are fashioned at the rate of one per minute those handsome thumb-screws which fix the attachments for binding, hemming, &c. When a screw is finished it is cut from the rod, and drops into a receiver, the rod, meantime, being drawn forward to supply material for another. The screws of simpler form are made at a much more rapid rate.

The most cursory glance at a sewing-machine will reveal the fact that it is composed of many parts of a great variety of shapes, and if it be remembered that The Singer Manufacturing Company produce

no fewer than seventy different types of machines, some notion of the number of parts that have to be operated upon in the course of a day may be formed. We have mentioned how a few of these parts are produced, and space forbids our doing much more than stating that, after passing through the machine shops, certain parts are polished, japanned, and ornamented with gilding, or it may be with mother-of-pearl. As the pieces proceed through the various departments they are subjected to rigid inspection, and to testing with standard gauges, so that no imperfect work is allowed to pass. The advantage of this exactitude in dealing with the separate parts is at once seen on entering the adjusting department, where the sewing-machines are put together. The parts drop into their places most readily, and without the use of either hammer or file. As the fitting is completed the machines are placed on a table and driven for a certain time at a high rate of speed, to test the strength of all their parts and ensure smoothness of working. They are next passed to female assistants, who put them to the test of actual sewing. Each machine is then subjected to a final close inspection, and transferred to the warehouse. Machines for family work are furnished with a case of valuable accessories, comprising interchangeable hemmers and folders, braider, and several other attachments. These are made of metal, electroplated with silver, and are produced in a special department of the factory.

In the cabinet- and box-making department a large number of machines are employed for sawing, planing, moulding, and other operations. The wood used in making the tables of the machines, the covers, and the drawers, is chiefly walnut. A staff of several hundred women is employed in French polishing.

For making and repairing the tools and machines used in the factory, there is a well-appointed workshop, which, taken independently of its surroundings, would be regarded as a considerable establishment. It contains about forty lathes, and a score of planing machines, besides drilling machines, slotting machines, milling machines, and other appliances. In a factory in which there is so much milling and drilling to be done, it is, of course, essential that there should be a department devoted to upholding the milling and drilling tools. No fewer than 4,000 milling cutters are kept constantly in stock in addition to the large number actually in use in the works.

To the business of sewing-machine manufacturers, in connection with which their name enjoys a world-wide reputation, The Singer Manufacturing Company have added that of makers of steam boilers under the Babcock and Wilcox patent. For this branch they have provided special workshops at Kilbowie.

The sewing-machine factory will be capable of turning out 10,000 machines per week, the production of which will give employment to 5,000 workpeople. Owing to the situation of the factory, the operatives are unable to find suitable house accommodation near, and four special trains are run each morning and evening by the North British Railway Company to convey them to their homes in Glasgow. The Singer Manufacturing Company, however, intend to build a number of cottages adjacent to the works, and this will be a great convenience, especially to the married members of their staff. The Kilbowie Factory is a "model establishment" in every sense of the term, and it is most ably presided over by Mr. Alexander Anderson, an old and faithful servant of the Company, a prince of organisers, and a gentleman who is held in the highest esteem by the industrial army which he commands.

While greatly extending their works at Glasgow, The Singer Manufacturing Company retain their factories at Elizabeth Port, New Jersey; at Cairo, Illinois; and at South Bend, Indiana, in the United States. The Elizabeth Port factory is one of the largest industrial establishments in America, covering twenty-five acres of ground. It turns out 250,000 sewing-machines per annum. At South Bend the walnut and mahogany required for all the machines made by the Company are cut up and reduced to shape. The Company have established a factory of considerable extent at Montreal, for the purpose of meeting the demands of their rapidly growing business in British North America. A similar establishment has also been opened at Floridsdorf, near Vienna, to supply their agencies in Austria, Hungary, &c.

While the Kilbowie and other factories are busy supplying the markets of the world with sewing-machines of seventy different kinds, ingenious minds are constantly at work for the Company, devising new forms and applications of mechanical stitchers. Many kinds of sewing work which it was long supposed could not be accomplished by machines are now done by their agency. The most familiar forms of The Singer Manufacturing Company's machines are those with reciprocating and oscillating shuttles respectively. These are

largely used for family work, and in clothing factories. But for special manufacturing purposes single and double chain-stitch machines are provided; and there are separate button-hole machines for operating on leather, cloth, and linen. One particular branch of manufacture required a machine which, while capable of stitching at an exceedingly rapid rate, should cut the edge of the work at the same time. The machine produced to meet these conditions is a marvel. It is so small that it may be carried in one's top-coat pocket, and yet it is capable of making 5,000 faultless stitches per minute. Another novelty is a machine for stitching together the cards of the Jacquard machines attached to looms used in weaving figured fabrics. Usually the cards are laced together by hand; but now they may be stitched by The Singer Manufacturing Company's new machine in one-tenth of the time, and with unfailing exactness.

We have mentioned one of the tiniest machines made by the Company, and we may now go to the other end of the scale and give a brief description of the largest machine they have yet produced. This gigantic stitcher weighs over four tons, and embraces some striking novelties in its working parts. It is adapted for general manufacturing purposes of the heavier sort, although specially made for stitching cotton belting, which has during the last few years come much into use as a serviceable substitute for gearing or ordinary leather belting. The material used for the belt is of great strength and toughness, and is sewn together in layers, the aggregate thickness in some cases exceeding an inch. The cloth is first carefully arranged fold upon fold, and then fed into the machine between iron rollers, nine inches in diameter, and over eight feet in length. There are two needles employed, and two shuttles, and the shuttles can be removed from their races without disturbing the overlying layers of belting.

In all the machines the mechanism has by successive improvements been reduced to a degree of simplicity that is truly wonderful. This fact will impress itself upon any one who, having the slightest knowledge of mechanism, will take the trouble to examine, say, one of the reciprocating shuttle family machines, which is perhaps the most widely known type. Apart from its table or stand—furnished with a treadle, crank, and driving-wheel—it consists of a bed-plate, above and below which is arranged the mechanism that gives motion to the needle, shuttle, and feeding apparatus. Securely fixed to one end of the plate is the "arm," which is virtually a tube bent at right angles, and stretching longitudinally over the plate at a height of five or six inches. In the upright portion of the arm is a shaft which derives a rotary motion from a fixture on the axle of the driving pulley. The latter axle extends the whole length of the horizontal part of the arm, and at its extremity the needle-bar is mounted in a perpendicular groove in the end of the arm, and receives an up-and-down motion through the agency of a cam fitted to it. The needle is attached to the lower end of the bar by a screw clamp. Close beside the needle-bar the "presser-foot" is mounted. Its function is to hold the cloth firmly while the needle is passing through it, and to assist in bringing forward fresh material. Below the bed-plate, and immediately under the aperture into which the needle dips, is the shuttle-race and the mechanism which carries the shuttle to and fro at each stitch. Through a slit in the needle-plate the "feed-dog" works. This is a lever with a portion of one of its ends raised and serrated. The "dog" has four motions, produced by a beautiful combination of cams and a lever. Its first motion is upward through the needle-plate, when it impinges the cloth which is being sewn against the presser-foot; then forward, carrying the cloth along the space of one stitch; then downward to clear the cloth; and, finally, backward to the position from which it started. Let the machine be set in motion, and observe what occurs. The shafts in the arm revolve, one actuating the needle-bar and the other the shuttle and feed-dog. The needle ascends, the feed-dog rises and brings forward the cloth the space of a stitch; the needle descends, and, jerking back a little way, throws out a loop of thread through which the shuttle glides at the proper moment. When the needle is completely withdrawn the shuttle returns to its first position. Two threads are used in sewing—the one carried by the needle, and the other by the shuttle—and it is by interlacing these that the sewing is accomplished. It is necessary that the threads should have a certain degree of tension imparted to them, and that is provided for by passing the upper thread round studs and between discs, which may be adjusted to any degree of straining, and leading the lower thread through slits and eyes in the sides of the shuttle.

Latterly The Singer Manufacturing Company have been giving considerable attention to the production of a family machine with an oscillating

shuttle, for which several distinct advantages are claimed. It is, if anything, simpler in its working parts than the machine just described, and at the same time it is capable of being driven at a considerably higher speed, while, as the shuttle spool carries a much larger quantity of thread, the work of replenishing comes at longer intervals. Another and important peculiarity is that the needle is the shortest of any in use in sewing-machines, and consequently possesses the greatest strength for penetration in relation to diameter. The arrangement for drawing up the slack thread is such as to admit of a heavier thread than usual being employed in proportion to the size of the needle; and at the same time a more faultless stitch is produced.

It but remains to state that for the service of their customers The Singer Manufacturing Company have nearly 4,500 branch offices rented by themselves, and attended by their own salaried employés. Of these offices, 403 are in the United Kingdom, 1,057 in other parts of Europe, and 3,040 in America, Asia, and Africa. The Headquarters of the Company are situated at 34, Union Square, New York. The Southern Europe, Africa, and Asia divisions of this vast organisation are controlled from the Central Office in London, which occupies a fine block of buildings in Foster Lane, Cheapside, and in which quite an army of clerks is employed. This most important and far-reaching department of the Company's business is ably presided over by Mr. John Whitie, who occasionally makes a tour of inspection, embracing a visit to three continents. For the service of Northern Europe there is a Central Office at Hamburg, under the superintendence of Herr G. Neidlinger. Taking the manufacturing and sale departments of the Company's business together the number of salaried servants is little, if at all, short of 50,000.

HEALTH AND DISEASE IN INDUSTRIAL OCCUPATIONS.—XI.

WORKERS IN PHOSPHORUS AND ARSENIC, AND THEIR DISEASES.

BY ANDREA RABAGLIATI, M.A., M.D., HONORARY SURGEON TO THE BRADFORD INFIRMARY.

IN speaking of this subject, I am happily in the position of being able not only to indicate an effectual remedy, but also to add that whenever that remedy has been employed, the evil effects of working in phosphorus have entirely disappeared. Phosphorus is one of those bodies capable, in the language of chemists, of existing in allotropic forms. That is to say, the same chemical body may take forms which, so far as appearance, colour, and physical characters generally are concerned, are entirely unlike one another. Common carbon, for example, may exist in the common black form which the name suggests, or it may take the form known as black-lead, and used in lead pencils, or it may exist perfectly pure, as the diamond. So with phosphorus, which may occur in the pale yellow form, which is most familiar, or in the less known red or amorphous (shapeless) form, to which further reference will be made in the course of this chapter. Now when the hurtful effects of phosphorus on health are spoken of, it is always the yellow phosphorus that is meant. The red or amorphous phosphorus has none, or none to speak of, and accordingly the simple remedy for the injurious effects of working in phosphorus is to substitute the red for the yellow variety. This entails, however, a little more expense in working, and hence the match-maker (for it is chiefly in this industry that phosphorus has any interest from our present point of view) who uses the red sort for the manufacture of his articles, cannot sell them so cheaply as he who uses the yellow or dangerous sort. Since cheapness appears to be the chief element that determines the sale of one article in preference to another of the same kind, the public have often unknowingly encouraged unhealthy occupations, and have also encouraged, by enabling them to succeed, manufacturers who cared little for the health of their hands, but much for making money for themselves, by simply buying the cheap and unhealthy article, and letting the dearer but safer one alone. In point of fact, of course, manufactures which are dangerous to health are also more costly even when the product can be sold more cheaply than that of less unhealthy occupations, since the former cost not only the price of the material, and the wages necessary for its manufacture, but also, in addition, the health of the operatives. Unhappily, however, many people are so poor that they are bound, for the sake of the subsistence of themselves

and their families, to do whatever work is offered them, however dangerous it may be to health; and masters have always been found who have been glad to take advantage of this necessity. In addition to this, it must not be forgotten that much of the suffering of the world arises from ignorance, and that in industrial life it is not known beforehand which occupations will prove healthy and which not. The decision of this question has hitherto been left to a rough sort of trial and error. It is to be hoped, however, that the diffusion of more knowledge on such points may enable the operatives better to know their own interests, which would certainly always be benefited if they were in the habit of exercising greater prudence and foresight. Perhaps, also, if the general public knew exactly how the matter stood in cases of this sort, they might not always, as at present, let cheapness alone decide them in favour of the purchase of one article rather than another. But whatever answer may in the future be given to such questions, more knowledge on the part of the operatives will enable them to demand increased remuneration for increased risk, to which surely no one will object.

The following is the history of the affections caused by phosphorus in persons exposed to the effects of the yellow variety.

For a certain period of time, differing in different cases, the operative feels pretty well. After this a certain disposition to a sort of influenza, accompanied by sneezing, is set up; and the operative suffers at first, occasionally, but afterwards more frequently from tooth-ache. These pains in the teeth, which may attack sound as well as diseased teeth, are of grave import to workers in phosphorus, particularly when they do not yield to ordinary treatment. After a longer exposure to the agent, the pain is no longer confined to the teeth, but spreads to the whole of the upper and lower jaws, and frequently strikes even over the whole face, and the neighbouring portions of the throat; the throat-glands swell and become painful, the gum becomes inflamed, and by-and-by the cheek participates in the swelling, and grows hard and tense. The gums are, for the most part, soft and elastic, particularly in the upper jaw, while on the lower abscesses frequently form, which discharge loathsome and putrid matter. The teeth on the affected side, whether they were at first decayed or not, become loose, and either fall out of themselves, or may be easily pulled out by the fingers. More abscesses now form on the gums, which lose their bright red colour, and become livid, and are so undermined by the matter as to suggest sometimes the appearance of a sieve, through the holes of which an offensive discharge wells up. In some cases the whole gum, the bone, the tissues composing the cheek, and even the throat, have been attacked and eaten away by this terrible malady. As a rule, the affection is of slow progress, particularly when the upper jaw is affected. These effects begin to manifest themselves, on an average, according to certain observations quoted by Dr. Hirt, to whom I am indebted for much valuable information on this and kindred subjects, in about five years after the operative commences work in a phosphorus factory. About eleven or twelve per cent. of those employed become, as a rule, affected by the disease, although this proportion varies with the amount of ventilation of the work-rooms and other preventive measures to be referred to. Men and women suffer equally in proportion to their numbers. As to age: of 40 cases quoted by Dr. Hirt, 5 were between the ages of 15 and 20 years; 13 between 20 and 25; 15 between 25 and 30; and 7 above 30 years of age.

Other forms of poisoning by phosphorus occasionally occur, which, though not very important in the arts, may be mentioned here. In these cases, persons who may be exposed to the vapour of phosphorus suffer either from a large quantity of the gas acting for a short time, or from smaller quantities acting over a longer time, or repeated from time to time. In the former case, or what may be called the acute, brachychronic form, the cause of death seems to be suffocation, before paralysis of the nervous system takes place, which would be the consequence if the vapour acted over a longer time. In one reported case, the person fell into a state of stupor, from which he never awoke. Chronic phosphorus-poisoning induces a leaden appearance of face, the persons exposed to the vapour wasting away with dry skin, irregular pulse, and great loss of power to withstand cold. Then ensue derangement of digestion, feverishness, pains in the chest and bones, partial paralysis, and death.

In the matter of prevention, some curious facts crop up. One of the most singular is the effect of turpentine in obviating the bad effects of phosphorus, both in the solid and the gaseous forms. It is asserted by some (though it is denied by others, and on the whole seems to be doubtful) that a certain proportion of turpentine vapour in the air breathed by operatives exposed to the *vapour* of

phosphorus will prevent the evil effects of that vapour. However this may be as regards the vapour, there can be no doubt that the oil of turpentine is a powerful antidote to the effects of phosphorus in the solid form. The reason of this is not very well known. It is said by some to be due to the fact that turpentine is very rich in oxygen gas, which is supposed to unite with the phosphorus and so prevent its injurious effects. This explanation derives some colour from the fact that the evil consequences of phosphorus-working do not occur to anything like the same extent in workshops which are well ventilated, and where, therefore, a large quantity of oxygen gas is admitted. Whatever the explanation may be, however, certain it is that when the employers place bowls filled with oil of turpentine at various points of workshops in which phosphorus is used, the consequent necrosis of the jaws is very soon seen to diminish. It is said that very few of the employers, even when they are aware of the value of turpentine as a preventive agent, care to employ it, and various reasons are given for this remarkable fact. One is that turpentine itself may have hurtful effects; and, in fact, this is the case. The vapour of turpentine, when inhaled in considerable quantity for a short time, affects first the breathing and the heart's action, and afterwards has an injurious effect on the brain and spinal cord. A kind of stupor is apt to supervene on the original excitement which it causes. If, on the other hand, turpentine vapour is inhaled for a longer time and in small quantities, scarcely any evil consequences result; but if there are any, the order in which the organs of the body are affected is the following. The greatest amount of influence is exerted on the lungs; the next greatest on the digestive organs; and, lastly, the brain and spinal cord may be acted on. As, however, these effects are in no case severe, and as it is not large doses of turpentine vapour which are recommended as the antidote to phosphorus, but the small and repeated ones, which have no permanently hurtful effects, the objection of employers to make use of the remedy is seen to have but little weight. Even if the effects of turpentine vapour in small and repeated doses had, however, much more effect than they possess, their evil influences would still be much less than those of yellow phosphorus, and it would therefore be the duty of the employers to use it as an antidote. Some of the masters are said to fail to use it from mere indolence, for which, of course, there is no excuse.

Other preventive measures have been recommended, as the drinking of alkaline waters, and particularly of lime water; but though these proposals have the merit of not being capable of doing any damage, it is doubtful whether they are of any use.

The real remedy for the evil effects of yellow or white phosphorus is that referred to in the opening of this chapter—the disuse of it, and its replacement by the red form. Discussions on this subject have taken place on the continent of Europe, notably in Germany and Italy, where it has been proposed to forbid by law the use of the yellow agent, and to allow only the employment of the red. This would be the last kind of weapon to employ, and one to which it may be necessary to have recourse in those countries as well as in France, where a great trade is still carried on with this deleterious agent. It is, however, a dangerous thing to liberty to have too much recourse to Government help to enable people to do what they are quite capable of performing for themselves unaided. Even when the Government interferes in the right direction, as would be the case in the present instance, its interference is to be deprecated, because it is antagonistic to that spirit of self-government and self-dependence which is of so much importance to a free and progressive people. But this objection would have to give way before the evidence, if such there were, of persistent deterioration of the health of the people. Happily, however, there is no such need and no such danger in the case before us. The English market has for some years been in the practical possession of manufacturers who make matches which are perfectly safe, both to the operatives engaged in the trade, and to the public who burn them. In their manufactory at Bow, Messrs. Bryant and May have conducted operations in this industry on a most extensive scale, without the use of white phosphorus; and they inform me that for the last eighteen years they have not had a single case of necrosis among their hands, nor of any disease which can be attributed to the occupation. This is not to be wondered at when it is considered that all modern improvements have been carried out at those works, and that, in addition, the red phosphorus which is employed is used only for the rough side of the box, on which the matches are struck, and not for the matches themselves.

As some authors have supposed, though with insufficient reason, that some of the bad effects of working in phosphorus are due to arsenical

vapours, I will say a few words here on the influence exerted by arsenic on those exposed to it. Working in arsenic can hardly be called a great British industry. Still, we hear from time to time of certain diseases caused by its presence in wall papers, and even in ladies' dresses, while the persons who dye the offensive colours occasionally suffer, as might have been anticipated. Only the chronic arsenical poisoning will be here referred to, since acute poisoning hardly ever occurs in the arts, and one may almost say never in this country. One of the most curious facts in connection with arsenic working is that a certain proportion of the work-people, and others who may be exposed to it, do not suffer at all. They may be exposed for years to its influence, and in considerable quantities, and yet show absolutely no effects from it. It may be mentioned, in passing, that certain mountaineers eat the metal in gradually increasing daily doses for the purpose of making firm their muscles, and of increasing their powers of wind. After a time these peasants take doses large enough to prove fatal to those who are unaccustomed to the agent. There is again another group of the workers in arsenic who are affected in a very slight manner, only amounting to a little involvement of the stomach, with occasionally some superficial ulceration about the mouth, and a feeling of dryness about the tongue and throat. Slight as the effects are, however, their long continuance is apt to pull down the strength of the operators, chiefly by interfering with their digestion. When "arsenicism," as the condition is often called, is well marked, a number of evils afflict those who are exposed to arsenic. These are long-continued affections of the skin, very itchy, very painful, and often very difficult to heal. Then affections of the joints and muscles are apt to occur, with chronic irritation about the eyes, which appear red, inflamed, and often watery. Lastly, the nervous system is apt to suffer much, and people complain of neuralgic pains, headaches, and numbness in various parts. They often sleep badly, and become melancholy and unsocial in their nature, while occasionally they suffer from hallucinations and delusions. Sometimes a well-marked and general wasting supervenes, which, if the cause is not removed, may put an end to life. These symptoms are sufficiently unlike those caused by phosphorus, to make it quite easy to distinguish the two; but as arsenic does sometimes occur as an impurity in phosphorus, and as some writers have confused the effects of the two things, I have thought it better to mention them here.

SHIP BUILDING.—XXVIII.

THE STRUCTURES OF ARMOURED SHIPS.

THE structural arrangements of armoured ships are necessarily of a very special character. Protective materials have to be used in great masses, and to be combined with the hull proper. The armoured portions of the broadsides have to be constructed with reference to their efficiency as targets, capable of withstanding the impact of heavy projectiles moving at very high velocities. The decks have not only to serve as platforms, carrying guns and other heavy concentrated weights, but are frequently wrought into the protective system, and covered with iron or steel plates of considerable thickness. Other means of offence besides the guns have to be arranged for in the design. The bows have to be made exceptionally strong for ramming; and a torpedo-armament is now the rule. Nor is armour the only defence provided. Extremely minute water-tight subdivision of the interior is a necessity, to guard, as far as possible, against the attacks of an enemy with the ram or torpedo. The coal is usually stowed in such a fashion as to protect the engines and boilers. The propelling apparatus has to be of relatively enormous power to drive these armoured monsters at the high speeds considered essential in modern battle-ships; and great strains have to be resisted at the parts of the structure to which the engines are attached. Numerous auxiliary engines are fitted to economise manual power, and to enable heavy weights to be dealt with. Steam power is applied to work the capstans, to steer the ships, to pump them out, to ventilate them, to throw water over any part where a fire may occur, to lift the boats, to hoist shot or shell, to revolve the turrets, and in other ways; while in some vessels the guns are loaded and worked by hydraulic machinery. Nearly every available space in the interior is appropriated to some specific purpose, and fitted for

the stowage of particular items in the stores or equipment. "A place for everything, and everything in its place" is a proverb distinctly applicable to the hold-stowage of war-ships. Elaborate arrangements are needed for safely carrying powder, shells, torpedoes, and other warlike stores. A war-ship has to be self-supporting for long periods of absence from port, and carries in consequence large reserves of stores. Complicated systems of pipes run through the ship for pumping out or flooding the various compartments, for use in case of fire, for the conveyance of steam to the auxiliary engines, &c. The numerous partitions in the hold are furnished with many water-tight doors, worked by suitable mechanism, and capable of being closed rapidly in case of collision or other accident. Voice-pipes, telegraphs, and other modes of communicating orders in action; electric apparatus of various kinds suited for firing the guns, or exhibiting a brilliant light when an attack by night is feared, and many other specialities which need not be mentioned, are all necessary in the modern war-ship, and all add both to the weight and the cost of her outfit.

During the last twenty years there has been continued growth in all directions, and the difficulties of the ship-builder have been increasing; for while, on the one hand, he has been called upon to add speciality to speciality, and to take nothing away which would compensate for the additions, he has been asked, on the other hand, to carry greater weights of armour and heavier guns. The designers of war-ships have, in short, been engaged in a ceaseless struggle to economise in the weights of the hulls in order that they might be able to increase the weights carried. Very considerable success has attended these endeavours, and it may be well to briefly indicate the principal methods in which weight has been saved while strength has not been unduly reduced. English naval architects have taken the lead in this matter, and foreigners have been content to follow that lead in all important particulars.

Three principal means of saving weight require attention. First, improvements in structural arrangements; second, alterations in the types of ships; thirdly, the substitution of steel for iron. The last-mentioned change is beginning to operate now most markedly; the first and second have been in progress for at least twenty years. In the *Warrior*, and other earlier ironclads, want of experience in iron-ship construction, and the desire to secure an ample margin of structural strength, led to the adoption of unnecessarily heavy arrangements, which have since given place to the "bracket-frame" system, briefly described on page 206, Vol. I. The advantages resulting from the change can best be illustrated by an example. In the *Defence*, an ironclad begun about 1860, the weight of the hull was about 3,500 tons, while the total of weights carried was 2,500 tons; that is, nearly 60 per cent. of the displacement was assigned to hull, and only 42 per cent. to the weights carried. About seven years later, the *Invincible* class of ironclads was designed by Sir E. J. Reed, of nearly identical dimensions with the *Defence*, but with improved structures. The hull of the *Invincible* weighs about 2,700 tons, and carries a burden of no less than 3,200 tons; so that only about 45 per cent. of the displacement is assigned to hull, and about 55 per cent. to the weights carried. It has been stated on the highest authority that had "the *Defence* been built on the system of the *Audacious*, and the armoured surface remained the same, while in all other particulars the ship was completed as she now stands, the saving in weight of hull would have been sufficient to have more than *doubled the thickness of armour*." This is not at all an exceptional case; for, speaking roundly, the change in system of construction has transferred 10 per cent. of the displacement from the hull to the carrying power in armoured ships of approximately the same size and of similar type.

Changes in type associated with the bracket-system of construction, enable still greater savings of weight to be made. For example, the substitution of low-sided mastless ships like the *Devastation* for high-sided rigged ships like the *Warrior*, has favoured reduction in the weight of hull. The *Black Prince*, a sister ship to the *Warrior*, had a weight of hull closely approaching 5,000 tons, her total weight (or displacement) being 9,250 tons. In the *Devastation*, of almost the same displacement, the weight of hull is less than 2,900 tons, or only 58 per cent. of the weight of hull in the *Black Prince*. This remarkable contrast is partly due to the fact that the *Devastation* is 100 feet shorter than the *Black Prince*, and partly to differences in form; but the main reasons for the saving in weight are those stated above. It is undoubtedly a triumph of constructive skill which enables the *Devastation*, on a hull weighing less than one-third of the displacement, to carry weights which in the aggregate exceed twice the weight of hull. Of vertical armour and backing she carries nearly 2,000 tons; of deck-armour she carries 550 tons, each of her

two turrets, with the guns therein, weighs nearly 350 tons, her propelling machinery and auxiliary engines weigh over 1,000 tons, and the total weight of coals, provisions, and equipment exceeds 2,000 tons. Yet this heavily-burdened and lightly-built vessel has been on service almost continuously for several years, has been tested at sea in some very heavy weather, and has shown no signs of weakness.

The introduction of steel renders still further progress possible. In a former chapter (Chap. XIII.) we have discussed the advantages which steel possesses over iron. It need only be added here that, although mild steel is at least 20 per cent. stronger than iron, no such percentage of saving can be obtained on the hulls of steel-built armoured ships. The reasons for this are obvious. First, it must be noted that in many minor parts of iron-built ships —such as bulkheads and internal partitions generally—the thicknesses of plating are already at their minimum, consistently with durability, and cannot be reduced if steel is used. Further, and still more important is it to remark, that the great weights of fittings which are included under the head of "hull," are not sensibly affected by the use of steel instead of iron. Exact estimates are not yet accessible as to the actual savings possible with steel, but it seems unlikely that they will exceed 10 or 12 per cent. of the corresponding weight of an iron hull. These are suggestive circumstances, which over-sanguine advocates of the use of steel sometimes overlook. We are strongly of opinion that steel will supplant iron as a material for ship-building, but desire to draw attention to the practical limitations which are placed upon the reductions in weight that steel renders possible in armoured ships. Of course it will be understood that steel-built ships gain in strength as compared with iron-built ships, owing to the existence of these limitations; but the margin of strength, except against local strains, is already very great in most armoured ships.

Passing from these general considerations, a few remarks on some special features in the structures of armoured ships may prove interesting. It has already been stated that thick plates of wrought-iron formed, until recently, the cuirass of all armoured ships. In the first floating batteries, which had wooden hulls, these slabs of wrought-iron were simply fitted upon the outside of the wood planking, and secured thereto by screw bolts. Something of the kind continued to be the practice in all wood-built ironclads; the principal difference consisting in the various modes of bolting the armour to the wood hull. The French were content to use bolts which did not pass through the whole thickness of the side, whereas English builders preferred "through-bolting," and trials at Shoeburyness proved their preference to be well-grounded. When iron hulls grew into favour, a less simple plan of combining the armour with the hull proper, became necessary. By common consent, after many experiments, it was decided to retain a teak-timber backing for the armour, and thus the thickness of the target, which had to be combined with the hull, varied from 1½ to 2½ feet. Within the teak backing an inner skin of thin iron plating is fitted, forming a back to the target, as shown in Fig. 1. The main framing of the target consists of vertical girders (*f f*, Fig. 1) placed two feet apart; and it is now the general practice to cross these by horizontal girders (*g*, Fig. 2) worked between the teak planks of the backing. It will be remembered that in no case does the armour extend more than six or seven feet below the water-line of a ship; so that from the lower edge of armour downwards an entirely different system of construction suffices, resembling in its main features the sketch on page 206, Vol. I. At the junction of the armoured and unarmoured parts, an "armour-shelf" is formed. Usually this shelf is "recessed," as shown in Fig. 2, and the outer surface of the armour forms a continuation of the surface of the bottom plating, so that a casual observer would not know from the outside appearance where the armour ceased. The true water-tight skin of the ship is continued by the armour-shelf and the skin-plating behind the armour, and it is not expected that the armour-plates will remain water-tight, although in English ships they are most carefully fitted together. In other cases the surface of the skin-plating behind the armour forms a continuation of the bottom plating, and the armour and backing "overhang," as shown in Fig. 3. This system was carried to an extreme in some of the American monitors, where the wood backing was worked of enormous thicknesses, and the overhang on each side reached four or five feet. It has been found that in ships thus constructed the blows of the sea upon the under side of the armour-shelf produce unpleasant shocks and vibrations, unless the space below the shelf is filled in by chocks of triangular cross section, as in Fig. 3. In some of the American monitors, hastily built and weakly put together, these shocks upon the very broad shelf-plates are said to have actually caused such separation of the parts as to produce

serious leaks. One good effect of the overhang deserves to be noticed, however; it undoubtedly tends to check heavy rolling, and probably helped

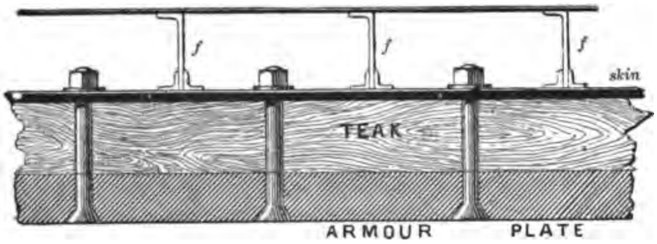


Fig. 1.—Horizontal Section of Armour side.

to establish the character of the monitors as very steady vessels. In all the most recent English ironclads the armour is recessed, and a similar

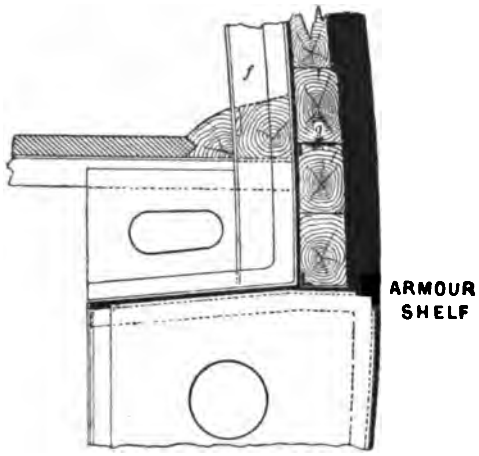


Fig. 2.—Armour Shelf "recessed."

arrangement is generally adopted in foreign ships.

One of the most difficult problems that had to be solved in the construction of ironclad ships was that relating to the armour-fastenings. In the earlier trials against targets it was found that very often when a projectile did not penetrate, its impact sufficed to break the bolts by which the armour-plates were fastened. These bolts (as shown in Fig. 1) passed completely through the target, the conical heads being buried in the armour-plates, while "nuts" were hove up on their inner ends within the skin-plating; and in most cases the bolts broke in the screw-thread cut to receive the nuts. Two devices have been adopted in order to render this kind of failure less probable. The first is illustrated in Fig. 4, and is known as an "elastic cup washer." It consists first of a wrought-iron cup, hexagonal in shape (marked *c*), into this is fitted an india-rubber washer (*d*), which is kept in place by an iron plate (*e*). When the armour-bolt has been driven through the armour, backing, and skin-plating, this cup washer, &c., is slipped over the point of the bolt, and the nut (*n*) is afterwards hove up tightly, pressing the flat surface of the cup (*c*) against the skin-plating. Then if the armour is struck by a projectile, the elasticity of the india-rubber washer assists in preventing fracture of the bolts at their

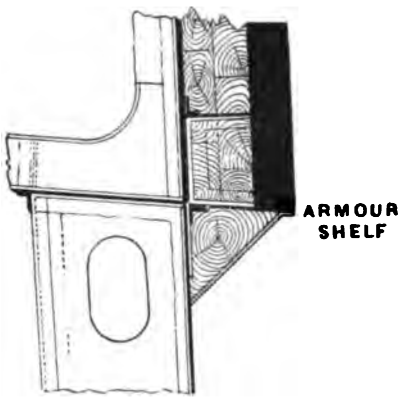


Fig. 3.—Armour Shelf "overhanging."

screwed points. The second device, which was introduced by Sir William Palliser, consists in reducing the shanks of the bolts, where they pass

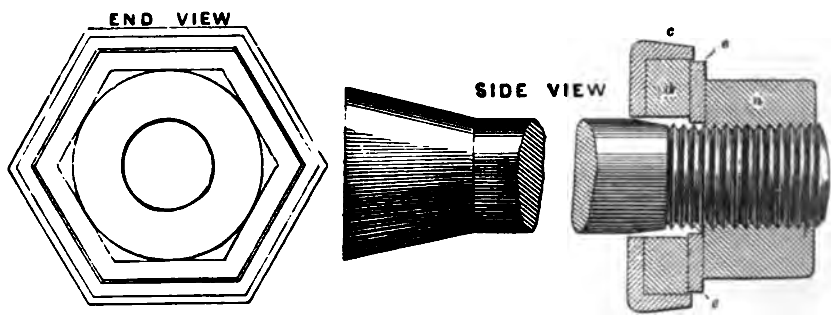


Fig. 4.—Elastic Cup Washer.

through the wood backing, to a diameter equal to that of the least diameter of the bolt where the screw-thread is cut. By forming this comparatively long space of nearly uniform strength, an opportunity

is afforded for the ductility of the iron to come into play, the bolts stretching instead of breaking when the target is struck.

At first it was thought that the perforation of the armour by numerous bolt-holes was a source of weakness, and various plans were proposed for avoiding through-fastenings. On the whole, however, conical-headed bolts (like those in Figs. 1 and 4) were preferred so long as wrought-iron armour kept its place. Now that steel and steel-faced armour are used a different plan finds favour. Instead of drilling holes completely through the armour-plates, they are drilled only about half through, from the back of the armour-plate. A screw-thread is cut in these holes, and into these the screwed points of the bolts are inserted. Instead of driving the bolts from outside the ship it is, therefore, now necessary to drive them from inside, and to make the bolt-holes in the backing sufficiently large to permit the bolts to be screwed up into the back of the armour. Many trials have been made in England and abroad with plates fastened in this manner, and good results have been obtained. Elastic cup washers and reduced shanks can, of course, be used in association with this mode of fastening. All armour-bolts need to be made of a very superior and ductile quality of iron or steel, of which samples are subjected to severe percussive tests before the bars represented by the test-pieces are accepted and used. Until quite recently wrought-iron alone was used for armour-bolts, but now "mild" steel, of the quality used in ship-building, is coming into use, and greater uniformity as well as greater excellence of quality may be expected in future.

Special machinery and plant of various kinds are required in ship-yards where armoured ships are built. The operations of bending and fitting various masses of iron weighing twenty or thirty tons, obviously require care and skill. Powerful hydraulic presses are now commonly used for the purpose, and when a considerable amount of work has to be done upon an armour-plate, it is heated in a special furnace. Some builders prefer to leave these operations to the manufacturers of the armour, and there can be no question but that in many cases this is an economical plan, although it necessitates the supply by the ship-builder of accurately-fashioned moulds, which guide the workmen in bending the plates. In the larger private yards and in the Royal Dockyards, special presses and planing or slotting machines are provided, and the manufacturers deliver the armour-plates flat, of sizes slightly exceeding the dimensions required in the finished plate. Nothing can be more interesting than to watch the preparation of a large armour-plate having considerable curvature; and it is wonderful to note the accuracy with which a perfect fit is secured, not merely against the surface of the wood backing, but against the edges and

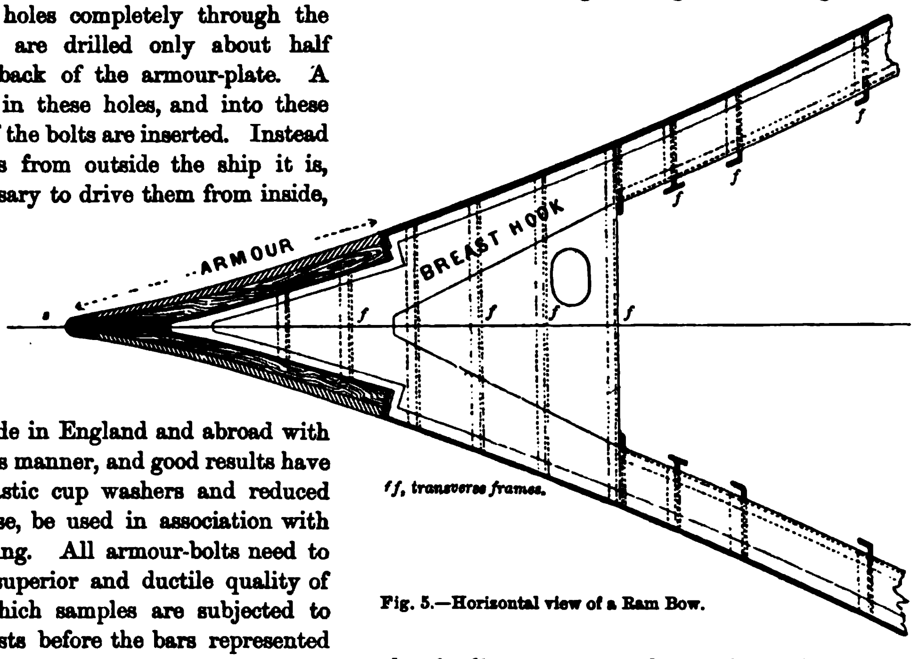


Fig. 5.—Horizontal view of a Ram Bow.

ends of adjacent armour-plates. Powerful cranes or "travellers" overhead are needed to lift large armour-plates into place, but under the management of experienced men, the handling of these great weights is effected with apparent ease. The real magnitude of the operations is only appreciated when they have to be performed by means of improvised appliances. The great outlay on plant and machinery necessary for the performance of all the operations incidental to building armoured ships, has limited the number of private establishments thoroughly equipped for this class of work. On the Thames the two principal establishments are Messrs. Samuda's and the Thames Ironworks; Messrs. Westwood and Bailey have built ironclads, but are now mainly engaged on civil engineering work; and the Millwall Ironworks, once such a scene of industry, are now deserted. On the Clyde, John Elder and Co. and Robert Napier and Co. stand almost alone in undertaking the construction of

ironclads. On the Mersey, Messrs. Laird Brothers, and on the Tyne, the Palmer Company at Jarrow, are worthy rivals of the other firms named. Besides these there are a few other firms which occasionally build armoured ships, and many others which on an emergency could be brought into work of the kind, although not specially equipped for it. No other country can compare with Great Britain in the power of producing rapidly war-ships of all types; but our relative superiority is greatest when the resources of this country for building armoured ships are compared with those of other nations.

Limits of space prevent any detailed description being given of the structural arrangements by which the bow of an armoured ship is made capable of ramming. Fig. 5 will enable some idea to be formed of the principal features. The stem, *s*, is formed of a solid iron forging, and this is usually "spur-shaped," the foremost point of the spur being about eight feet below water, and projecting several feet forward. This contour of the stem is adopted in order that when ramming an enemy, the blow may take effect mainly on his comparatively weak sides below the armour. The stem *s* is supported by a series of horizontal breast-hooks, of which one is shown in Fig. 5, and by the side-armour of the belt, if the belt extends from stem to stern. The breast-hooks and outside-plating of the bow are stiffened by numerous vertical and transverse frames; and numerous water-tight partitions are fitted near the bow, so that, in case of damage in ramming, the space to which water can find access is very limited. By these and other means such strength can be given to a ram-bow that it will be but little damaged in many cases of collision. The *Iron Duke* struck the *Vanguard* such a blow as to sink the latter, but her bow was not at all damaged, and she could have safely rammed again, had she been in action. Circumstances may occur, of course, where more serious damage is done, as was the case when the German ironclad *König Wilhelm* rammed and sank her consort, the *Grosser Kurfürst*. But in that case the bow of the *König Wilhelm* was not so strongly built or so well-arranged as the bows of more recent ships have been.

In conclusion, we can only briefly refer to the minuteness of the water-tight sub-division which is now carried out in armoured ships, as the best possible defence against rams and torpedoes. It is hopeless to make the sides and bottoms strong enough to resist either of these modes of attack; all that can be done is to limit their effects as much as possible. Recent ships have been much more minutely sub-divided than their predecessors, although from the very first great care was taken in English ironclads. The *Warrior* had no less than 92 separate water-tight compartments, the *Hercules* had 61, the *Devastation* 104, the *Alexandra* 115, and the *Inflexible* 135. This policy of minute sub-division has been adopted by all foreign nations in their recent ships.

COTTON.—XXVIII.

THE COTTON MANUFACTURE IN IRELAND—THE SEWED MUSLIN TRADE.

BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

SO closely did the people of Ireland confine their attention to the linen manufacture that it was not until a considerable time after the spinning and weaving of cotton had been established in England and Scotland that they engaged in that branch of business. About the year 1756 cotton yarns of a low quality were made to a small extent at both Dublin and Cork, and were used as weft in the production of sheetings and tickings, the warp being formed of flax yarn. In 1776 a cotton spinning-mill and hand-loom weaving factory were erected on the shore of the Bay of Allen, in Kildare, and a large number of cottages of a superior kind were at the same time built for the accommodation of the operatives. The new settlement was happily named Prosperous, and so successful did its first cotton-mill prove that in the course of half-a-dozen years four other factories were constructed, and the population of the place had risen to over 3,000. Calico printing and bleaching had also been introduced. The cost of living was cheap in the district in those days, and as a consequence, the operatives could afford to work for a wage that now seems ridiculously small. Men employed as weavers earned 7s. and spinners 10s. per week, women and girls 6d., and children from 2d. to 3d. per day. The hours of labour were from fifteen to eighteen per day.

Mr. Robert Joy, a newspaper proprietor of Belfast, paid a visit to Scotland in the autumn of 1776, and when travelling through Lanarkshire was struck by the progress made by the cotton manufacture and the prosperity of those engaged in it. At that time the Irish linen manufacture had received a check through the American war, and it occurred to Mr. Joy that it would be well to try to plant the cotton manufacture in Belfast, and so supply the people with employment. On returning home he mentioned his idea to some friends, and the result was that he and Mr. Thomas McCabe, a watchmaker, entered into partnership, and began business as cotton spinners. They were granted the use of some unoccupied rooms in the poor-house, and these they furnished with hand spinning-wheels of improved construction. Their venture provided occupation for about a hundred women and girls, and the yarn produced met with a ready sale. This encouraged the firm to extend their operations, and they procured from Glasgow a spinning-jenny capable of spinning sixty threads at a time. This machine was accommodated in a hay-loft, and was for a time an object of much curiosity. A new partner, Capt. M'Crackin, was assumed about this period, and the business of the firm was rapidly extended. In the course of a little time they were the owners of a spinning-mill fitted with the best appliances then known. Their success induced others to embark in the trade, and soon the town could boast of several cotton spinning mills. In other parts of the north of Ireland mills were also built. It was ascertained that there were in Belfast in 1782 about 500 looms employed in weaving cotton. Lisburn, Newtownards, and Hillsborough had become seats of the trade, their productions holding a high reputation in the market. One of the Lisburn mills merits special notice. It was erected in 1789 by Mr. James Wallace, in a situation where water-power was not available for driving the machinery. The choice lay between horse-power and the then novel steam-engine of Watt. After due inquiry and a visit to Glasgow, Mr. Wallace resolved to employ steam, and he set up a fifteen horse-power engine, which was the first prime mover of the kind introduced into the north of Ireland. In 1793 another steam-propelled cotton-mill was built at Lisburn. Such were the vicissitudes of trade in those days, that by the year 1812 the cotton-mills of Lisburn were entirely abandoned, owing, probably, to the spinners not being able to hold their own in the market against their Lancashire competitors, who had new machinery at their command of a greatly improved kind. Muslin weaving, however, gave employment to many hands. At the close of last century it was estimated that about 30,000 persons were employed in the cotton manufacture in Ireland, and that the capital invested in machinery, &c., was not less than £350,000. In the year 1800 ten thousand bales of raw cotton were worked up in the cotton mills of Ulster.

Owing to various causes, the persons engaged in the cotton manufacture had to submit to a reduction of wages in the years 1814–5, and this gave rise to great discontent, and engendered much bitterness between employers and employed. The workmen combined and "swore out of the trade" such masters as were particularly obnoxious to them. The result of being so sworn was that no weaver in the combination would either weave a web or permit others to weave a web for the offending master. A prominent Belfast manufacturer, Mr. Francis Johnston, was sworn out in 1815, and not only so, but his life was threatened, and an attempt was made to burn down his house. A few months later a more determined attempt was made to destroy Mr. Johnston and his household. A box filled with explosives, and fitted with a match, was thrown into the house during the night. A servant caught the depredators at work, and, without knowing the nature of the contents of the box, removed it to the kitchen, where it exploded and wrecked a large part of the house, but fortunately without harming the inmates. An attack with firearms was then made upon Mr. Johnston, but assistance arrived in time to prevent bloodshed. Three men suffered on the gallows for this offence; two others were imprisoned for eighteen months with hard labour, and the addition of three hundred lashes each.

During the next few years the cotton trade underwent considerable fluctuation, and the difficulties between the masters and their men continued. An important incident in the history of the trade was the abolition of the protective duties which were levied in Ireland on British and foreign-made cottons. These duties were continued for twenty years after the Union, but obviously without having the desired effect upon Irish industry. Touching this occasion the author of "Ireland and Her Staple Manufactures" says:—"From 1802 to 1811 the import of raw cotton had increased from 1,200,200 lbs. to 5,950,800 lbs., but in 1820 only 3,058,954 lbs. had been imported into Ireland. Mr. Huskisson was then engaged in untying the swaddling bands by which

commerce had been bound, and at the close of the session of 1821 he stated that the time had come when all restrictive enactments connected with the trade of the United Kingdom should be swept away. That announcement was heard on this side the Channel with dismay; meetings of manufacturers were held in Dublin and Belfast, and petitions, teeming with doleful forebodings of the results of free trade, were next session poured into the House of Commons. In one of these documents it was prophesied that the repeal of the protection duties would give a deadly blow to the manufacture, and cause capitalists to seek in another country the 'justice denied them at home.' 'If the trade with Britain be thrown open,' continued the petitioners, 'the 40,000 hands now engaged in the cotton manufacture, and the 3,000 people employed at print-works, will be deprived of work, and all our capital will be destroyed.' But the Ministry listened not to the lamentations of those dismal soothsayers, and in the session of 1823 the Act for the imposition of import duties was repealed, and the international trade left free. Scarcely had the new law come into existence when, in direct opposition to the sombre seerdom of protectionists, Ireland's cotton manufacture burst into more active life, and a demand, previously unknown, arose in the west of Scotland for Ulster-made muslin."

Immediately, as the writer above quoted states, on the repeal of the protective duties good results followed. The people of Ireland were able to supply themselves at reasonable prices with the fancy goods and high-class cambrics of Lancashire and Lanark, and the Irish muslin weavers found their hands full of orders from merchants and printers in both those counties. The year 1824 was one of remarkable prosperity for the textile industries generally; and it was in that year that the demands of the Glasgow weavers on their employers for repeated advances of wages resulted in great benefit to the north of Ireland. Labour was much cheaper in the latter country than in Scotland, and rather than comply with the demands of their weavers beyond a certain point, several of the larger Glasgow manufacturers sent agents to Ireland, and had their goods woven there. The local manufacturers were stimulated to increased activity by this movement, and for a time great prosperity prevailed. In 1826 came that disastrous collapse of inflated speculations which resulted in the stoppage of banks and a general disturbance of commerce and industry. The Irish muslin weavers ceased to find occupation, and were in a little time reduced to great straits. Public subscriptions were opened for their relief, and employment in the shape of stone-breaking was provided for such as could engage in it. The wages of the few men who continued to work at the loom did not exceed six shillings per week.

In the course of the following year, however, things began to mend, and for nearly ten years the muslin weavers had a fair run of prosperity. Cotton spinning still continued to engage attention, and in 1830 there was a score of mills at work in Belfast and the neighbourhood. That year is remarkable in the history of the trade as having witnessed the beginning of a change which resulted in driving cotton spinning out of Ireland nearly altogether. Messrs. Mulholland, of Belfast, who were engaged in cotton spinning to a large extent, built a new mill, but before the machinery was put in the idea occurred to them that it might be better to devote the building to the production of linen rather than of cotton yarns. Inquiries on the subject led to their adopting this idea, and they accordingly fitted up the new mill with flax spinning machinery. This was the first establishment of the kind in the town, and its career was watched closely by the cotton spinners, and also by flax spinners in various parts of the country. It was not long in proving a success, and the result was that other mills to spin flax by steam-power were erected, while several of the existing cotton-mills were adapted to spinning flax. In 1874 there were only eight cotton factories in Ireland, in which there were 108,086 spinning spindles, 3,374 doubling spindles, 2,558 power-looms, and the total number of persons employed was 3,075. The return made in 1879, however, shows a considerable reduction of these figures. In that year there were in Ireland only six cotton factories, containing 78,528 spindles and 2,686 power-looms, and giving employment to 1,620 persons.

Though the production of cotton yarns almost ceased to be a branch of industry in Ireland after the success of the flax spinning mills had been demonstrated, muslin weaving on the hand-loom continued to be a large and increasing branch of trade for many years. The greater proportion of this work was done for Glasgow firms, who found it profitable to avail themselves of the comparatively low price of labour which prevailed in Belfast and neighbourhood.

In reviewing the progress of the cotton manufacture in Ireland, a writer furnishes the following

interesting particulars:—"From the year 1830, when the spinning of flaxen yarns was first introduced into Belfast, the trade of cotton spinning fell off, but that of muslin manufacturing increased, until the quantities of hand-loom goods produced in the cotton weaving districts in and around the town exceeded very much those made in all the west of Scotland. The agents of Glasgow houses gave employment to vast numbers of hands, and the local manufacturers, especially those of Belfast, did at least four times the amount of business usual in the days when they were protected by high duties from the competition of their British brethren. Newtownards, which may be called the Paisley of Ulster, had long been famed for the skill of its fancy weavers; but after the advent of the agents of Glasgow houses, and the greater demand for all varieties of fancy cotton goods, increased vitality was infused into the trade, and the skill of the 'harness' weavers rose into genius of a high order. For many years past vast quantities of the fancy fabrics woven in Newtownards, after having been sent across the Channel and finished in Glasgow, were sold there to the belles of St. Mungo as the genuine production of the looms of Paisley. It would be difficult to give a correct statement of the amount of wages paid away by all the agents who gave out weaving for Scottish employers, but in the stirring year of 1853 the average sums so distributed by four agents engaged in a town some miles distant from Belfast exceeded £1,500 a week. And while the stream of capital was flowing in regular rivulets, and bringing comfort and independence to hundreds, nay thousands of homes, the manufacturers of the town were employing their full share of the operative labour, and doing an amount of business exceeding anything of which those who wailed over the demise of protection, some thirty years before, never entertained the most distant idea."

No account of the cotton trade of Ireland would be complete that did not mention the sewed muslin branch, which for a time afforded a large amount of employment to the people. The ornamentation of muslin on the tambour frame was practised in various parts of the country towards the close of last century, and appears to have first received attention from Miss M'Crackin of Belfast, a relative of the Captain M'Crackin already mentioned as one of the proprietors of the earliest cotton spinning-mill in Belfast. This lady instructed a number of girls in the art, and found a ready sale for all the articles they produced. Her success encouraged others to engage in the business, and it gradually extended throughout the north. Paisley was at that time famous for its work of this kind, and Mr. John M'Ferran, of Lambeg, went to that town to acquire a knowledge of the trade. On his return, in 1803, he opened an establishment for training girls to embroider according to the latest methods. Several years later a muslin manufacturer at Lisburn added the embroidering branch to his business, and secured the services of a Scottish lady to instruct his work-people.

Finding that the Irish peasants could turn out satisfactory work at a cheaper rate than they had to pay at home, some of the Scottish houses in the trade began, about the year 1830, to send agents to Ireland to employ the young women of that country. Large numbers of the latter had been thrown out of employment in the rural districts through the spinning of flax having been transferred from the hand-wheel to the machines. But the agents encountered serious difficulties in the way of inducing the women to apply themselves to the new work. With the more intelligent residents of the towns it was easy enough to make progress, but when it was sought to carry the industry into remote parts, obstacles of various kinds were encountered. The people could not understand why any one should open a school for teaching sewing gratis, and they became suspicious and shy. In one village the report was sent abroad that all the pupils were to be sent to Australia as soon as they learned to embroider, that their parents would never see them again, and that in reality the schools were part of a scheme to decoy children from their parents for proselytising purposes. The intervention of the clergymen had to be sought to remove this delusion from the minds of the people. A graphic description of other obstacles to the introduction of the trade into the more obscure parts is given by the author of "Ireland and Her Staple Manufactures." He says:—"In the mountainous district of Donegal many of the poor girls—wild and untrained as the aborigines of the far south, and still more neglected than the denizens of those distant lands which call forth so much interest in Exeter Hall—gave immense trouble to their teachers. Numbers of those natives of the rude sea-coast and rugged hill-side, though sixteen years of age, did not know how to thread a needle, and had no idea of using a thimble. Great care was taken to teach them how to hold the sewing-hoops, but once they got over the preliminary lessons the instructors had the gratification of seeing them work with comparative

ease, and able to earn fair wages. But amid all the anxiety consequent on the instruction of these girls, there was much of the ludicrous, and still more that was amusing, in their occasional expressions of impatience. After an hour or two of diligent labour, some sturdy girl would straighten up her back, stretch out her arms, and drawl out, 'Och, och, wirra! an' isn't the weary work all out? My heart's broke wid it. It is wheelin' the turf or settin' praties I should be at instead of sittin' here stitchin'."

In course of time, however, all difficulties were got over, and the work of the Irish women became highly esteemed in the market. Specimens shown at the Great Exhibition of 1851 attracted wide attention to Irish sewed muslin, and at that time it was a highly fashionable article of adornment with the ladies, not only of this country, but of the United States and various European kingdoms. At the Exhibition referred to a handkerchief sewn in Newtownards for a Scottish house was considered one of the finest specimens of this kind of work ever produced. It was valued at twenty guineas. One Glasgow house paid to Irish sewers alone in the first six months of 1851 no less than £63,400, and for the same period of 1853 they paid £90,000. At that time, and for several years after, no town in the north of Ireland, from Derry to Dublin on one hand, and from Belfast to Sligo on the other, was without its sewing agent, and in some towns five or six agents were required. It was estimated that no fewer than 80,000 women and girls were employed in the muslin sewing business in Ireland at this time, and their earnings ranged from 3s. to 10s. per week. Dark days were at hand, however. Many persons had rushed into a business which was regarded as being highly remunerative, and the result was over-production. Every market became gorged, and the low price at which the embroidered goods were sold made them so common that they palled upon the popular taste, and went out of fashion. In the commercial crisis of 1857 the trade suffered severely, and the Irish peasant girls found that the occupation which had been so irksome to learn was gone. Great hardships ensued, as might be expected. At intervals since then a limited demand for hand-sewn muslins has been experienced, but that the trade will ever reach its former extent is extremely unlikely. Embroidering machines have been invented which turn out work as beautiful, if not more so, than the hand used to do, and as that work is comparatively cheap it is likely to meet most requirements. The machine embroidery, it must be said, however, is not so durable as that produced by hand.

WOOL AND WORSTED.—XXV.

BRADFORD: ITS TRADE AND SPECIALITIES.—THIRD PAPER.

By William Gibson.

WITHIN a radius of five or six miles of Bradford there are fifty or sixty villages, so-called, having from five to ten thousand inhabitants each, and all of them, to a greater or less extent, dependent upon the central emporium, while beyond these villages, again, is a second *cordon* of large towns—Halifax, Keighley, Leeds, Wakefield, Dewsbury, and Huddersfield—which have considerable interest in her trade being brisk. Among the names which have always stood at the head of Bradford trade, scarcely one is strange to the locality, and most of them are sprung from the yeoman class that have for generations held farms in the dales round the town. And at the present moment a considerable proportion of the pieces and yarn exposed at the weekly market bear the trade-mark of men who, in the olden time, bestrode the pack-horse, or shouldered the sack, to travel through valley and over moor, in all weathers, at the dawn of the stuff-trade of the West Riding. We shall now take a rapid glance at some of the chief hives of industry that surround Bradford.

Beginning at the south-west corner of the inner circle, we are arrested at once by the noble pile of buildings, with its palatial entrance, and neatly arranged boundary and ornamental grounds, known as Black Dike Mills. The village of Queensbury which, fifty years ago, consisted of a few cottages and a farmstead or two perched on the crown of a wind-beaten moor, numbers not less than 8,000 souls, all of whom depend upon the weekly payments of Messrs. Foster and Son. The founder of this gigantic firm, John Foster, belonged to an old Thornton family, as the tablets in the parish church abundantly testify. Born at Moor Royd Gate, in 1789, he was educated at the Grammar School of

his native parish, and subsequently at Brook House School, where he formed an acquaintance, that ripened through the years that followed, with another celebrated manufacturer—Jonathan Ackroyd, of Halifax. Foster married, in 1819, a daughter of the Briggs family, with whom, among other substantial advantages, he became possessor of Black Dike Farm, Queensbury. Removing, after his marriage, to Low Fold, near that village, he learned the worsted trade, and in due time, started in business for himself in a small way. His own buyer, traveller, and agent, he employed an ever-increasing number of hand-loom weavers, spinners, and combers, principally in the damask and lastings line; but as machinery began to be introduced he found it necessary to rent Cannon Mill, Great Horton, as a spinning factory, about the year 1832, and to build the old Black Dike Mill three years later. At that time he had 700 weavers hard at work in Queensbury and the vicinity, and in the old mill 4,000 spindles were running. A very fair idea of the growth of the business may be obtained from the fact that within forty years these 4,000 spindles had risen to 50,000, and considering the increased speed and efficiency of the newer machines, the difference represents an increase of something like twenty-fold. In 1836 he was among the first to introduce the power-loom, though he still continued to employ many hand-loom weavers, and the following year he began to drop the manufacture of sheep's wool in favour of alpaca and mohair. But Mr. Foster was not permitted to supplant manual labour by mechanical in peace. As was the case in the experience of other manufacturers, "the plug" and other rioters of 1842 paid him a visit; and, as they failed to gain an entrance to the factory, walked off with all the provisions of the workpeople upon which they could lay their hands. The Queensbury manufacturer, however, held on his way, and there were, in 1843, 500 power-looms at work in his weaving-sheds. This number has been added to from year to year, and now the works cover thirteen acres of ground, and give employment to no less than 3,500 hands. As the business grew, mill was added to mill, and shed to shed, the old structures being pulled down and replaced by new from designs drawn by the owner. Quickly as the Black Dike premises grew, the necessities of trade compelled Mr. Foster to occupy factories outside his own freehold. Netherton, Wellington, and Ramsden's Mills were all "run," in addition to the three or four at Queensbury. The Shed Mill was built in 1846, Victoria Mill and the adjoining shed ten years later; then a splendid wool warehouse and combing-shed, with offices, grease-works, gas-works, and other necessary adjuncts to so large a concern, besides some four or five hundred cottages for the accommodation of the workpeople. Although constructed at different periods the various buildings display a uniform design, and the useful and ornamental are intimately combined. The Victoria and Shed Mills have each a frontage of 475 feet, are five storeys in height, built of stone, with fire-proof flooring, and filled with the best patterns of spinning, roving, and other machines. Between these lie the weaving and combing-sheds, in the former of which are a thousand looms, and in the latter the very best specimens of Lister's and Noble's splendid mechanical combers, that work with such rapidity as almost to make the annual product assume fabulous proportions. The wool warehouse, which is 350 feet long, is a storey higher than the spinning mills, is flanked by a warehouse for "tops," or combed wool. These structures lie to the rear of the premises, and are arranged on a novel and convenient plan. Each of the six floors is divided into two compartments: one for the storage, and the other for the manipulation of the various wools employed by the firm. The warehouse is fitted with hydraulic lifts in order to obviate the tedious and tiresome process of climbing up stairs. The top floor is entirely packed with raw material, alpaca and mohair in one division, English and Colonial wools in the other. Below some 175 wool-sorters are busy on the fifth and fourth floors with hair from Angora and Peru, and on the third floor there are more wool-sorters entirely taken up with home and Australian wools. The second storey is devoted to the arrangement and storage of "noils," and the ground floor is sacred to the warp-dressers and their attendants. Close to the warehouse are the washing and drying sheds, grease and soap works, and other offices. In the cleansing department ten Petrie and McNaught washers are continually at work, and these insatiable gluttons consume 8,000 pounds of soft soap weekly, which is manufactured on the spot. This enormous amount of lubricant, however, does duty over and over again, for the suds, as they are drawn from the washers, are carefully tanked, filtered, chemically treated to preserve the grease, the water being eventually further purified before being allowed to float into an adjoining beck. Over this washing-room are the drying chambers, constructed on a plan, and fitted with huge cage-like

apparatus invented by the founder of the firm. The motive power for driving all this vast and complicated machinery is obtained from coal dug out of the mines belonging to the firm, and shot into the furnaces by waggons running upon tramways. The furnaces themselves are fitted with Vicar's feeders and burners, and heat some twenty-two multitubular boilers fitted with Green's fuel economiser feeds, which re-inject the condensed steam at a temperature of about 250°. The original engine close by the old mill is of thirty-five horse-power nominal; but those which drive the machinery in the Victoria and Shed Mills are a pair of splendid compound condensers, constructed by the Bowling Company, and working up to 1,000 horse-power each. The room in which these machines work is the show-place of the establishment, and is worth a long journey to see. Without any fuss or noise these silent slaves work through the livelong day, and the enormous fly-wheel attached to them, which weighs some fifty tons, whirls noiselessly on its well-poised bearings. Every bit of steel about the place is polished to the utmost extent, and all the fittings and settings are beautifully clean and neat. The indicated force of these engines is 1,700 horse-power, and so perfectly are the coals consumed that at no time can the wayfarer see more than a thin stream of bluish smoke issue from the ornamental shaft that carries it into the free air.

From this brief sketch it will be seen that Black Dike Mills is a very complete establishment. The raw material enters the works at one end, and leaves it in every conceivable make and pattern of finished stuff at the other. The looms turn out a piece per minute, 2,600 yards per hour, or, in round numbers, 9,500,000 yards of woven material every year. In order to do this 15,000 packs of wool are used, and the wages bill amounts to £109,000 a year. The founder of this gigantic business lived to see it arrive at its present huge proportions. He began by riding with the weekly product of his looms to Halifax, which was, at that time, the most accessible market, and ended by occupying an immense warehouse in Well Street, Bradford, with clients in every part of Europe, America, and the colonies. The firm still retains the original title, but the sons and grandsons are now the active proprietors.

Another firm rejoicing in the same surname as that at Queensbury has a business—in a different line—almost as large, at Denholme. The Brothers W. and H. Foster came to that village in 1830, having previously carried on a small trade at Duckhill, near Hebden Bridge. It is now no secret that they were able to put into the Denholme concern only £110 each, and the plant of the modern works was estimated a few years ago to be worth over £200,000. There was originally a third brother in the firm, but shortly after the formation of the Denholme partnership he came to a tragic end. In January, 1831, he had gone out into the district to deliver "tops" and collect "pieces" from the scattered weavers. Benjamin Foster was accompanied by his favourite dog Ship, and on the evening of the 4th he had got as far on his homeward journey as Wadsworth. He had a rugged valley to pass through and a wild moor to cross before he got to Denholme, and though a heavy storm of wind and snow came on, he refused the hospitality of his humble clients or the more tempting shelter of a wayside inn. He got as far as the edge of the moor when the storm came down with increased violence, but though he and his horse knew the road well, they turned to the right instead of the left, Ship trotting soberly along under the cart. Shortly afterwards the horse floundered into a morass from which turf had been cut to a depth of a couple of yards, and Foster was thrown violently out on the frozen ground. Despite his wounds and bruises, he scrambled up, and Ship followed him unmurmuringly. They had not proceeded far before a second mishap occurred, worse than the first. Quite out of his reckoning, and blinded by the snow which the wind blew in his face, he fell into a bog, was unable to extricate himself, and there he was found dead and partially covered with snow next morning, his faithful companion stretched across his breast.

Accidents of this kind were by no means uncommon in the days when "tops" had to be distributed by manufacturers, or weavers were their own "pack-horses;" the country being difficult to travel in, the homesteads widely separated, and the roads, or rather tracks, execrably bad. But the young firm met with further disasters before the era of prosperity set in. They began to build their first factory in 1838, and it was blown down the following year. A second building on a larger scale was erected in its place, which ran with ever-growing notoriety for some years, but this one was destroyed by fire in 1857, and £15,000 was paid by the insurance companies on account of the ascertained loss. The present extensive premises, covering ten acres of ground, were then built, on either side of the main road between Keighley and Halifax,

and there being no stream adjacent to feed the boilers, immense reservoirs, extending over an additional ten acres, had to be constructed for the purpose. The spinning-mill is 450 feet long and six storeys in height, and behind it are the weaving and combing sheds, and beyond these is an old mill which was saved in the fire of 1857. The weaving-shed is 244 by 200 feet, and contains 800 power-looms. On the opposite side of the high road, facing the larger factory, are the warehouses and other offices, also six storeys high, and communication between them and the spinning departments is obtained by a covered verandah thrown across from the sixth floor. All these buildings are fitted with the best machinery and every modern appliance, some 1,500 people find employment within their walls, and over £1,000 a week are paid in wages. Since the death of the junior partner in 1858, and of his elder brother four years afterwards, the amount of cloth manufactured has been more than doubled. These manufacturers have always confined themselves to the fabrication of lastings and camblets, of which class of goods they are the largest makers in the kingdom, and all the processes are carried out on the premises.

We have stated elsewhere that between Leeds and Bradford considerable quantities of woollen cloths are manufactured, and it will be convenient to take in a group the chief centres of this industry, near the latter town. Five "big villages" are still engaged in cloth weaving and milling—Eccleshill, Calverley, Farsley, Pudsey, and Gomersal. In all others worsted goods are made to a greater or less extent, but they are chiefly engaged in producing woollen fabrics. Super West of England, Venetians, Victorias, diagonals, Spanish stripes, and cabinet cloths are the chief varieties made in these busy places, and while in most of them the best modern mechanical and scientific auxiliaries are at work, there yet lingers the old-fashioned hand-loom. For the most part the products of the factories and master weavers are milled and finished in Leeds, but it is not so many years since the old fulling-stocks at Shipley were abolished. When the woollen weavers were obliged to resort to this suburb of Bradford to get their cloth felted, they had to take their turns as a pair of stocks was disengaged, and were frequently seen trudging home with their work in sacks towards sunrise the following morning. Calverley is perhaps the place where woollen cloths were earliest manufactured, and, strange to say, it is here the primitive hand-looms have continued to be used down to the most recent date in preference to machinery. The first factory in which modern appliances were exclusively used was built only a few years ago, and some of the older hands may yet be found shaking their heads at the "paahr-leums," and bewailing the grand old days of "t' owd maister"—Abimelech Hamsworth, "owd Bim," as he is yet affectionately called by those who remember his death in 1836. The descendants of "Bim" are now the principal manufacturers in the place, and it is almost needless to say they are the chief sinners in the machinery way. Pudsey long ago became notorious as the dirtiest woollen village in Yorkshire, a renown it still possesses. Ellwand, Thackrah, and Messrs. Varley and Stanningley are the chief firms; the latter employ about a thousand workmen, and are the largest makers in the neighbourhood. It may be added that there is a large worsted factory in Pudsey, run by a joint-stock concern—the Worsted Mill Company—which has 850 looms at work; and it may be explained that the dirtiness of Pudsey is accounted for by the number of coal-mines adjoining the village. At Eccleshill there are five or six woollen factories, the largest being that of Messrs. Smith and Hutton. Gomersal is also an old woollen village, and it had the additional distinction of once possessing a Cloth Hall. There is rather a curious story told about this building. The ground for its erection was given, it is said, by Sir James Ibbetson, on condition that when the premises ceased to be used for that specific purpose it should revert to the owner of the soil. This contingency took place, and the Cloth Hall Mills at present occupied by Messrs. Burnley stand on its site. Messrs. Burnley are engaged in the fabrication of knitting worsteds and Scottish fingering yarns.

Thornton—besides its industrial—has considerable national and historical interest. The township has been long and honourably associated with the Craven family, and the author of "Jane Eyre" has cast a literary lustre upon it, which to some extent overrides its commercial importance. In the chapter on Shawls and Tartans we explained that shawl centres were largely woven in the Bradford district, and Thornton is the centre of this branch of trade. Joseph Craven is the principal maker of this class of goods, and his patent for fringing has been very largely adopted elsewhere. The shawl-cloth is generally known as Indiana or Cashmere, is dyed chiefly black, and has become a staple product. Besides this material, Thornton is engaged in the production of various all-wool fabrics, as well as union cloth—such as Coburgs,

Orleans, Italians, Baratheas, and fancy textures. Another large manufactory of alpaca, mohair, and worsted goods is found at Buttershaw. Messrs. Bottomley, the owners of Buttershaw Roughs Mill, belong to an old Shelf family, and originally started business at Brighouse, and afterwards moved to Low Moor. The mill on the Roughs—so called from the huge boulders overgrown with furze for which the district is distinguished—was built in 1852, and its extent may be guessed when we state that there are 950 looms at work on the premises, and that 1,500 people are directly employed by the firm.

Wilsden, another extensive village, is the centre of the moreen trade in the vicinity of Bradford. The chief factory is known as the Old Mill, owned by Messrs. Tweedy, Anderson, and Co. Mr. George Tweedy, the founder of the firm, was engaged in another branch of manufacture when one of his customers asked him to send them a parcel of moreens. He did his best, but failed to produce the right kind of cloth—or, at any rate, such material as could be sold. Finding himself baulked, he had resort to a *ruse*. Dressing himself as a workman, he went to Brighouse, and becoming familiar with the methods of the best makers, returned to Wilsden, and entered upon a profitable career. His partner, John Anderson, had long been known as "the nice maker" by his Bradford compatriots, and the new firm speedily became famous for the beauty and regularity of their fabrics. The firm added to moreens the manufacture of damasks in 1828, and ever since both materials have been the staple products of the house. A Manchester firm, some thirty years ago, which was engaged in the delaine trade, came to Wilsden, intending to set up a factory in that line of business. They brought with them a new power-loom, arranged to weave two pieces on the same machine, but the ignorant weavers, fearing that they would be reduced to starvation if such implements were permitted, fomented a riot and drove the firm from the district.

Another characteristic branch of the Bradford trade is the production of heald and genappe yarns; and among the largest makers in the district are Messrs. Townend Brothers, of Cullingworth. They also manufacture large quantities of poplins, besides fancy mohair goods. Messrs. Townend's establishment is one of the most complete in Yorkshire, and, as is usual among manufacturers in this district, the firm is notable for the kind way in which they treat their work-people and the long time they retain their hands. It is one of the features of the Bradford employers of labour that men, and women too, are often, so to speak, born under the shadow of the works, labour in them all their lives, and die in harness under their old masters. A somewhat notable instance of this life-long connection between capital and labour occurred in connection with the firm of Townend Brothers. A workman who died in 1854 had been connected with Cullingworth Mills since 1808. During this period of forty-six years he had lived almost continuously at Denholme, and it was calculated that in walking to and from his daily labour he had covered the enormous distance of 53,664 miles.

Returning to a remark we made in the first Bradford chapter, regarding the thrift and frugality of the men who have built up princely establishments within and around the town, it may not be amiss to refer briefly to the career of Mr. James Hargreaves of Frizinghall—the ancient patrimony of the Listers of Manningham. Hargreaves was originally a small farmer, and occupied land at Delph Hill, Bolton. In order to improve the winter months and his yearly income, he went to Mr. Garnett, bought small quantities of yarn from him, and wove it in his spare hours. The increment to the profits of his bit of land could not, on the most liberal computation, have added much to his annual earnings, but he steadily and conscientiously forbore spending a penny of the winnings of his loom. As soon as these enabled him to do so, he began tentatively to buy a little wool, have it combed by some neighbours, spun at home, and then wove as much of it as he could. Mrs. Hargreaves was quite as industrious in this extra-agricultural occupation as himself. She could always be depended upon for keeping mentally a correct account of every half-pound or pound of "tops" distributed, and systematically collected the spun-yarn from week to week, in all weathers. In the course of a few years this self-denial, industry, and assiduity bore golden fruit. Frizinghall being in the market, Hargreaves got possession of it, and built there a small factory in 1779. The works were added to from decade to decade by the son and grandson, and now some 1,500 operatives are employed by the firm, which is one of the most enterprising and successful in its own department near Bradford.

INDUSTRIAL ART.—VIII.

ART IN GLASS.—FIRST PAPER—HISTORIC INTRODUCTION.

By John Forbes-Robertson, Author of "The Great Painters of Christendom."

When one looks upon the fragments of a broken bottle or a sheet of glass, one is painfully impressed with the fragile character of the materials which the accident or the passion of a moment could thus dash into a thousand pitiful shivers. We almost attach moral responsibility to the useless pieces, and regard them with unconscious reproach, not altogether untinged with contempt. The same feeling accompanies us when a favourite glass goblet or mirror comes to untimely grief, and the exclamation of regret, as in instances of another kind, is quickly followed by a sigh of relief, inasmuch as the supreme moment of its destiny, for which we now fancy we had long been waiting, has come and gone, and there is a final end to the thankless object of our quondam solicitude and regard. We give orders that the fragments—nay, the veriest vestiges—of the frail thing be swept from our sight at once and for ever.

Yet, if we but consider for a moment the marvellous functions which the material, in one shape or another, has fulfilled, the feeling of contempt ought to give place to one approaching somewhat that of reverence, even when the thing of use or beauty lies at our feet in shattered and formless atoms. Since man first discovered the art of producing and utilising fire, there is none of his many inventions which has so widened his knowledge and advanced his civilisation. Had its modern uses and capacities been known in the night of time, the material would have been held sacred. Indeed, the ancient Egyptians fashioned on their glass finger-rings the images and emblems of their gods.

The petulant but all accomplished and devoted Pliny, whose legacy to the ages is a compilation so unspeakingly precious, says, in recounting the marvellous facts connected with fire, that "it cannot recur to us but with a feeling of admiration that there is hardly any process which is not perfected through the intervention of fire. Submit to its action some sandy soil, and in one place it will yield glass, in another silver, in another minium, and in others, again, lead, and its several varieties, pigments, and numerous medicaments. It is through the agency of fire that stones are melted into copper; by fire that iron is produced and subdued to our purposes; by fire that gold is purified; by fire, too, that the stone is calcined which is to hold together the walls of our houses. . . . An element this of immense, of boundless power, and as to which it is a matter of doubt whether it does not create even more than it destroys." Had the eloquent naturalist dreamt of the many hidden mysteries which the modern manipulation of glass has revealed to us, he would have thought it still more wonder-working than fire; and even his abounding nomenclature would barely have sufficed to exhaust the category of its virtues. We can imagine him saying, "While we sit in our chamber we are surrounded by objects which minister to our comfort, our instruction, and delight. Without moving from our seat, we can watch the approach of a friend while yet afar off, and trace his loved lineaments when he himself is but a speck in the distance; we can gaze upon the raging of the storm without, and yet not a breath of it visit our warm cheek; and if we wish to behold our own beauty—for the finger of heaven has been on every countenance, and vanity is part of the heritage of man—we can at once gratify our desire without any fear of sharing the fate of Narcissus. We can note at our leisure the varying fortunes of the fierce war which is waged within the boundary of a drop of water—a microcosm quite other from that of the philosophers—and turning to the telescope, we can follow the motion, though we may not hear the music, of countless spheres, which never came within the ken of the star-gazers of Chaldæa. When we enter the solemn temples dedicated to the gods, the soul is warmed into reverential awe and piety, as their glory becomes almost visible and felt in the iris-coloured radiance which fills the sacred fane. And when at last the frail tenure of our tearful life is closed, and our hopes and fears and all our passions and impossible longings are stilled in Nature's greatest blessing, Death, the vitreous urn receives and conserves for our children's children the sacred ashes of their sires. Verily, glass is of immense and boundless power, and it is difficult to imagine a period to its marvels."

Although Isidorus, the geographer, and after him, as we have seen, Pliny, the naturalist—whose statements are in a measure endorsed by Strabo, the Greek geographer, and by Tacitus and Josephus, the historians—have made ample reference to glass, strange to say, modern writers for a long time

imagined that the material was unknown to the ancients. Indeed, if classical authority is to have any weight, more than four hundred years before any of these men wrote, Aristophanes in his "Acharnians," makes the Ambassadors say, "And being entertained with hospitality, we drank against our wills, from cups of glass and golden chalices, sweet unmixed wine." Pliny lost his life, as his nephew relates with touching circumstantiality, while noting the phenomena which accompanied the entombment of Pompeii, in A.D. 79; and it was not till the accidental re-discovery of the forgotten city, in 1748, and the excavations which followed thereon a few years afterwards, that the learned world of modern times became satisfied, by ocular demonstration, of the rare excellence the ancients had attained in the manufacture of glass. After describing the sandy shore of the little river Belus, which rises in the lower ridges of Mount Carmel, and enters the sea "near the colony of Ptolemais in Syria, in a region known as Phœnice, adjoining to Judæa," the laborious Pliny narrates the glass legend in this wise:—"The story is that a ship laden with nitrum (which Beckmann thinks could scarcely be our saltpetre, but was probably a mineral alkali) being moored upon this spot, the merchants, while preparing their repast upon the sea-shore, finding no stones at hand for supporting their cauldrons, employed for the purpose some lumps of nitre which they had taken from the vessel. Upon its being subjected to the action of the fire, in combination with the sand of the sea-shore, they beheld transparent streams flowing forth of a liquid hitherto unknown: this, it is said, was the origin of glass." Tacitus is briefer and less circumstantial, and Josephus makes the incident take place in a forest to which the children of Israel had accidentally set fire. The story is pretty, and, we can conceive, possible; but many chemists, Sauzay alleges, "explicitly deny that at any period it was possible to liquefy in the open air substances which, in our day and with our improved processes, can only be fused by means of furnaces constructed expressly for the purpose, and which concentrate a heat of 1,000° to 1,500° centigrade (Fahr., 1,832° to 2,732°)." Waiving the scientific question, we would remark that the Sidonians, in whose neighbourhood the alleged discovery was made, took up the art and carried it to a high degree of perfection. "Sidon," says Pliny, "was formerly famous for its glass houses, for it was this place which first invented mirrors." But whether Pliny's expression of *excogitaverat* means here "had invented," or only "had thought of," we leave critics to decide. The Jews of the Apostle Paul's time (whether the word ἔσοπτρον, used in the passage, "For now we see through a glass darkly," means glass, or some other translucent substance) were evidently, as we learn from

PERSIAN BOTTLE AND LAMP IN GLASS.

several other striking passages in the New Testament, familiar with the thing; and one could almost be certain that the author of the Apocalypse had gazed on a glass furnace in full activity from the remarkable passage beginning, "And I saw, as it were, a sea of glass mingled with fire." About the meaning of the adjective employed in this passage there is no doubt: it is ὑάλινην—glassy, which he joins to the beautiful Xenophonian word, of memorable use, θάλασσαν. What purple was to Tyre glass was to Sidon, and its manufacture became to the Phœnician city the source of its wealth and greatness; and, if we would seek for a parallel to this in medieval times, we would point to the wool of Bruges, and if in our own, to the cotton of Manchester.

GERMAN DRINKING VESSELS IN GLASS

The question as regards priority of invention, like the scientific one, must be left, to a certain extent, undecided. Yet, if we would be guided by historic analogy, there is little cause for hesitation or doubt. We would turn away from the shores of Sidon and direct our inquiring steps along the banks of the Nile, and try to find in the immemorial birth-place of whatever the Western world knows of religion and art some trace of an article whose service to mankind has been so stupendously important, and whose uses will become almost exhaustless as time rolls on. Nor would our pursuit after knowledge in this region be in vain. The paintings on the tombs of Beni-Hassan, quoted by Sir J. G. Wilkinson, show palpably enough that the dwellers in the Hundred-gated Thebes understood and practised the art of glass-blowing; and the same high authority describes a moulded

glass bead belonging to the necklace of a Theban queen who flourished fifteen hundred years before Christian chronology began. A legend is impressed upon this royal bead in sunken hieroglyphics; but, says M. Théodulfe Devéria, as quoted by M. A. Sauzay, "only the first line of this legend is legible. It may be translated without difficulty as follows:—'The good goddess (*i.e.*, the queen) Ra-ma-ka, the loved of Athor, protectress of Thebes.'" Some Egyptologists, indeed, assert, and not without reason, that the Thebans were well acquainted with the art of glass-making, not only when the children of Israel were yet in the land of bondage, but generations before the Lord called Abraham out of Haran, and blessed him with the promise that He would make of him a great nation.

Assigning a period so remote to a manufacture which is associated in the popular mind with times so modern looks at first sight like a wanton and useless raid into the region of the incredible. But distant though the date of the discovery be, living research and scholarship, and countless specimens in the British Museum, both for use and ornamentation, alike proclaim the stupendous antiquity of glass-working. Through all the many conquests to which Egypt had to submit she still retained an active familiarity with the beautiful art; and when at last she bowed to the Roman yoke, Cæsar Augustus ordered that part of the tribute should be paid in glass. The immediate result of this was to extend the manufacture, and Alexandria carried on an immense export trade. But by another generation (*i.e.*, during the first quarter of the first Christian century) this monopoly had ceased, and the Romans, instructed by their new colonists, had not only acquired the art for themselves, but were able to rival the most beautiful specimens the Egyptians had brought them "both in shape, colour, and cutting."

Pliny the Elder, while denouncing and bewailing the extravagant follies of the times, proceeds to give an example. "During his ædileship, and only for the temporary purposes of a few days, Scaurus executed the greatest work that has ever been made by the hands of man, even when intended to be of everlasting duration: his Theatre, I mean. This building consisted of three storeys, supported on three hundred and sixty columns. . . . The ground storey was of marble, the second of glass—a species of luxury which ever since that time has been quite unheard of—and the highest of gilded wood. The lowermost columns were eight-and-thirty feet in height, and placed between these columns were brazen statues three thousand in number. The area of this theatre afforded accommodation for eighty thousand spectators." If the Romans could build of glass the whole second storey of a building like this, the manufacture must have been of very great importance indeed. Glass, as well as translucent talc, has been found in the window-frames of some of the houses of Pompeii. But the Romans, like the Egyptians before them, turned their knowledge of glass-making to purely artistic as well as to ordinarily useful purposes. "In the time of the Emperor Nero," says Pliny, "there was a process discovered by which two small glass cups were made of the kind called *petroti* (or '*pterotos*' 'with winged handles,' as some read), the price of which was no less than six thousand *sestertia!*" or nearly fifty thousand pounds sterling. The clearer the glass, and the more resembling crystal, so much the more was it esteemed in the days of Nero (54 to 67 A.D.) and for long after. In a previous reign, namely, in that of Tiberius (14 to 36 A.D.), Pliny says, "a combination was devised which produced a malleable or flexible glass; but the shop and tools of the artist were totally destroyed, we are told, in order to prevent the value of copper, silver, and gold, from becoming depreciated;" and Dion Cassius informs us that Tiberius ordered the artist to be put to death.

It would be curiously interesting, and in some cases suggestive to the modern experimentalist, were a list compiled of the arts lost to us, but which were familiar to the ancients. Within the last four or five years, for example, tumblers and goblets made of what is called "toughened glass" have been hailed as something new, and have become—it is to be regretted, rather in a limited degree—an article of commerce. Their non-liability to break when submitted to the ordinary accidents of the table endears them to the frugal housewife; but this same quality would appear to make them obnoxious to the "trade." We see, however, that "toughened glass" is no new invention, and that the thing was known to the Romans eighteen centuries ago. So late as 1610, indeed, the art, according to Knolles, was known to the Persians; for among other rare presents sent by the King to Philip III. of Spain, to induce him to send his "dreadfull fleet into the Persian Gulfe" to aid him in driving Solyman, the Turkish Sultan, out of those parts of the East belonging to his ancestors in Babylon and Caire, there were six drinking-glasses, made of malleable glass, so exquisitely tempered, he tells us,

that they could not be broken. As the passage is quaint and not without interest, there needs no apology for quoting it. After showing the Spanish King how easily with his "dreadfull fleet in the Persian Gulfe, he could make himself Lord of Syria and of Egypt," Knolles goes on:— "Last of all he reckoned up the presents he sent him; to wit, the images of Ismael, Iuchel, and of Ionas, together with his owne, cast in gold, and set with most pretious stones and pearles; a Persian writing table, garnished with faire pretious stones, foure dogs by nature wonderfully spotted with red, yellow, and blew spots; two peeces of Arras adorned with most pretious stones and pearle, wherein the worthy acts of him, that great Tamberlane, were liuely to be seene; foure hunters hornes very smooth and richly garnished; twelue most gallant plumes of feathers, of diuers colours; six drinking glasses which could not be broken; and couchbeds so cunningly made, as that they were like vnto chaires, hauing wrought in them the antient wars betwixt Ascanius and Chiusa, King of the Medes." And here it may be mentioned that the purer, thinner, and finer a glass goblet is the less likelihood is there of its being broken. Now that the art of making glass malleable appears to be, in a measure, restored, there is no saying to what marvellous expansion and use experimental chemistry may not carry the discovery.

The immediate inheritrix of the Roman art of glass-making was, doubtless, Venice; and although we cannot agree with those of her historians who assert that the birth of Venetian glass-making was contemporary with the foundation of the city, we have no hesitation in asserting that the manufacture was in active operation long before a single furnace was removed to the little island of Murano, in A.D. 1289. In order to prevent the art of glass-making from passing into other lands, the Council of Ten passed a law in the last degree tyrannical and vengeful. "If, in spite of the imprisonment of his relations," it says, referring to those of the workman who has carried his art into a foreign country, and refuses to return, "he should persist in remaining abroad, an emissary will be charged to kill him;" and cases are on record in which the threat was carried out to the letter.

The chemists of Venice were as eager in the practical pursuit of their studies as her navigators were daring in the prosecution of their voyages. By the close of the thirteenth century the Venetians had recovered the lost arts of blowing false pearls and producing imitation gems, and much to the enhancement of her wealth and her renown, she extended her trade in these articles, formed into rosaries and the like, to the utmost boundaries of the then known world. In spite, however, of the deadly jealousy with which the Venetian State guarded its monopoly, the secrets of the art gradually oozed out, and by the middle of the sixteenth century German glass-workers had acquired a reputation for decorating their drinking-glasses with enamelled paintings, chiefly of armorial bearings. The enameller's art, however, it must be remembered, was known ages before in the farthest East. "In China, India, Persia, and Asia Minor," says Jacquemart, "it goes back to the remotest antiquity."

The Germans were followed by the Bohemians, who, early in the seventeenth century, had invented the process of engraving on glass. They often exercised their skill, moreover, on Venetian objects of the fifteenth and sixteenth centuries, things combining in one article, according to M. Sauzay, two industries separated by more than a century.

Turning to our own country, "Glass-making in Britain," says Apsley Pellatt, "is supposed to be of very ancient date; and, if the opinion of Pennant be well founded, of a period prior to the Norman Conquest. The art of manufacturing glass into such ornaments as beads and amulets was certainly known to the Danes, and glass vessels were made by the Anglo-Saxons." His authority for this last statement is the *Journal of the British Archæological Association.* The first English glass-houses, according to Pennant, for the manufacture of fine glass were those of the Savoy and Crutched Friars, established about the middle of the sixteenth century. It appears, however, that the English manufactures were for a considerable time much inferior to the Venetian; for in 1635, nearly a hundred years later, Sir Robert Mansell obtained a monopoly for importing the fine Venetian drinking-glasses. The art of making these vessels was not brought to perfection in this country till the reign of William III. Our glass manufacture has since made rapid progress, and the white crystal glass-works of England indisputably excel, at this moment, those of any other country. England is, Apsley Pellatt concludes, "pre-eminent for her refractive, colourless flint-glass for chandeliers and table articles; and the transparent metallic colours are of superior quality. With such materials, when artistic education becomes more extended, the English glass-makers will, it is hoped, rival their continental competitors in colouring, gilding, and elegant forms."

POTTERY AND PORCELAIN.—X.

MESSRS. MINTON'S WORKS, STOKE-ON-TRENT—STATUARY—PAINTING ON PORCELAIN.

By James Francis McCarthy.

IN the last chapter was told the simple story of the origin, progress, and development of one of the greatest china works in the world. That account may now be supplemented with a brief description of what may be seen any working-day at Messrs. Minton's manufactory, in the heart of Stoke-on-Trent. In every department the influences of the most skilled and progressive labour are felt. There is no purposeless waste of power here. The facilities for carrying on the processes are so perfect, and withal so simple, that energy is never aimlessly mis-spent, as is often the case in other large manufactories. The arrangement of the works is such, that as one operation is finished, the ware passes directly, and without any loss of time, into the hands of the workman who has to advance it yet another stage in its manufacture. The materials which are used in the formation of the soft clay are of the best; and it is scarcely within range of ordinary calculation to say how many tons pass every week through the "slip" house, and receive, at the hands of the potter, shape and consistency. There are two distinct and separate departments: the earthenware and the china works. A glance at the former may serve to show us processes very much like those which have been previously mentioned, but somewhat dissimilar in the results which they produce. In the first place, the "slip" house—the term now conveys its specific meaning—at Messrs. Minton's is a large, high-roofed building, light and cheerful, and scrupulously clean. The arrangements of the various shopping are those which favour facility in the progressive branches of the industry. The soft clay is, therefore, quickly passed into the potter's hands. Even in ordinary earthenware articles, the superiority of the clay is at once noticeable. It is not only that the various substances are in themselves excellent, but they have been so carefully blended as to produce a very fine and superior body to the ware. The operations of throwing, hollow-ware pressing, and moulding, are performed with skill and dexterity, and the greatest finish is given to every article.

Whilst passing through the earthenware department, an opportunity is afforded of seeing a great deal of statuary work. There is scarcely a household in England in which some specimen of this work may not be seen. For the most part, the finest results in statuary work are produced in porcelain, parian, the higher kinds of earthenware, or imitation Carrara stone. The clayey substances must be perfect in any case, and pulverised flint is mixed with the slip. Now let us see how carefully and tenderly the work has to be undertaken. A statue—about three feet high—has just been finished, the subject being an "Abyssinian slave." Every feature is beautifully worked out; every limb is gracefully and truthfully turned. But mark with what care this had to be performed. In the first place, a model of the figure had to be produced by the artist, and then from this model a series of moulds, representing the different parts of the figure, is made. In this instance there are ten parts, but in some statuary work there are as many as fifty. Anything in the nature of detail, involving curvatures, will necessarily involve a greater number of separate moulds than more simple work. The parts are then joined together by an outer casing of wood; and through an orifice, which is purposely made, is poured the clay. It is of about the consistency of cream. It clings to the various parts of the model, and as the mould itself, being of plaster of Paris, is absorbent, the clay leaves a fine coating, whilst the water has disappeared. In order to obtain the exact thickness, this process very often has to be repeated three or four times; every time a fresh layer of clay being added. But the absorbent nature of the mould has caused a skrinkage of about an inch and a half in the height of the intended figure. When the clay has dried, the various parts are put together by the "figure" makers; and bit by bit we see the whole statue literally pieced together. The seams which have been produced in casting—precisely like those seen after the operation of casting molten iron—are carefully effaced with a small steel tool, surface-blemishes are removed, and a face or a limb is touched up as an artist touches up the figures on his canvas. The work now appears a duplicate rendering of the original model. The figure is next put in a "muffle" to dry, and evaporation of moisture causes another shrinkage of one and a half inches. When it is placed in the biscuit kiln, where the fire is so mercilessly fierce, the figure, which in its ductile state was three feet, has

now shrunk to two feet six inches. It is clear, therefore, that to produce a piece of statuary of any defined dimensions, the greatest skill and judgment must be used in estimating for this diminution. This is one of the reasons why the best kind of statuary is so dear. When the work is finished to perfection, there is no branch of the potter's art which is more lovely as a piece of ingenious labour —labour turning formless clay into graceful beauty. Like other kinds of pottery, statuary is capable of much decoration, either simple or elaborate, as taste or custom may dictate. Some of the decoration may frequently have been observed in the raised beading, pressed on to the surface of the ware. When touched with gold, then it shines like a circling of auric stars. The decoration in colours is very nearly as effective as that which is seen on dinner-services, although the nature of the ware does not permit of such freedom of treatment. Some figures will take as long as three or four days to finish; but others, and more ordinary ones, may be made in a day. Besides this statuary work in the earthenware section, there is manufactured majolica of the finest description. Not long ago there was made a monster fountain of majolica, about ten feet high, and supported at the base by imitation storks. This piece of work took many weeks to complete, and the firing of it greatly taxed the patience and ingenuity of the workmen. The decoration in the same department is of the highest class, and the transfer printing by lithography, which has already been noticed, is seen to perfection at Minton's. The designs, showing great taste, are transferred to the surface of the ware with extreme delicacy—such delicacy, indeed, as to often favour the idea that it is hand-painting.

The mention of hand-painting arouses a desire to see the porcelain department on the opposite side of the road. As far as the shopping is concerned, this establishment is almost precisely the same as the earthenware department. The processes, too, are alike; but the clay used for best porcelain is incomparably superior. The workmanship which is bestowed on it requires the highest skill. This is particularly demonstrated in the production of egg-shell china. In "throwing" the cups for a miniature service of this description, the greatest delicacy is needed, and very often repeated attempts have to be made before success is secured. It is the same with plates and dishes, made in the same exquisitely fragile manner, and it is no uncommon thing for an egg-shell service to occupy many weeks before completion; indeed, a whole day may pass away before a few cups have been perfectly made. When finished they have to be cautiously fired, lest the least surface blemish, fissure, or other defect should mar the intended beauty of outline. Afterwards, the ware is enamelled, and in connection with this operation, "ground laying" is generally necessary. On all designs to which it is applied, a coating of boiled oil, specially prepared for the purpose, is laid upon the ware with a pencil, and afterwards levelled, or "bossed," until the surface is absolutely uniform. The colour, which is in a state of fine powder, is dusted on to the oiled surface with cotton-wool. It easily clings, and sometimes forms the only kind of ornamentation. In other cases, where it is necessary to pick out in white any given design on the ground-work of colour, stencilling is resorted to. The stencil, usually consisting of a mixture of rose pink, sugar, and water, is placed on the ware, according to the required design, with a pencil. The surface of the ware at the same time is entirely protected. The stencil having been dried, to harden the oil and colour, the ware is afterwards immersed in water. For higher evidences of ornamentation we have to look in another direction. We shall see it best in the painters' rooms. These apartments are not much larger than ordinary dwelling-rooms, and generally run in parallel rows on both sides of one square of the building. They are so constructed at Messrs. Minton's that they have a comfortable and homely appearance, and a certain air of tranquillity, which contrasts strangely with the intense earnestness of the more mechanical and rapid labour which is seen in other parts of the establishment. Most of these rooms are occupied by a group of three or four workers—actual labouring artists; but there are others, regarded with almost sacred privacy, which are alone reserved for the principal artists and designers, who receive very large remuneration for the creations of their fancy, and who are looked upon as the princes of their profession. They are all men of culture and long training, and there are some whose names have long since become "familiar in our mouths as household words." From the hands of these workers—for they are workers in art—come precious pieces of porcelain, with designs outlined on them. These are passed to the group of artists just alluded to.

It has been previously stated that the enamel colours used in painting on porcelain are produced from metallic oxides. A little more knowledge of these oxides shows us what power they possess in connection with the ornamentation of pottery.

Those who are not familiar with the industry may be surprised to learn that when incorporated with a fusible flux, gold, precipitated with tin, produces, after the firing, a crimson, rose, or purple colour; that oxides of iron and chrome give a red tint; that the same oxides furnish black and brown; whilst a delicate orange colour comes from a combination of the oxides of uranium, chromium, antimony, and iron. The flux, which gives cohesive power to the colours, is a composition of borax, flint, oxides of lead, &c. These elements are mixed with oils, and this process of mixing is an art in itself, an art which is constantly developing and disclosing lovelier results. We shall lose no time in seeing what is done with these colours. Several painters are at work in one of the rooms. They are exercising their art on the completion of a service of 300 pieces for her Majesty the Queen. The pattern is the simple one, emblematic of the three nations—the rose, shamrock, and thistle. This is the bordering which surrounds the central royal monogram, worked in gold on a raised blue enamel ground. The gold work, which appears in solid relief, is affixed to the ware by the power of white enamels. How easily, and yet how dexterously, do these painters ply their brushes, inlaying the design in every outline with dingy streaks of colour; how quietly the time slips away, until the pieces of ware are nearly covered with this dusky, unlovely-looking paint! You see the dingy evidences of the pattern as marked by these oxides and oils, and there is no beauty in it whatever. But turn your eyes for a moment to the ware that has passed through the fire. The effect is almost incredible. The roses have opened their petals in crimson and deep red hues, which the oxides and the fire have produced; the shamrocks appear as they do in Nature's fields; and how delicately the thistles stand, encircled by a garland of oak-leaves of every shade! This, bear in mind, is painting underneath the glaze, which is generally resorted to. The firing of the glaze is very protracted, and is often attended with great risk. Of the painting on the glaze, the effect seems to be heightened, because the power and the charm of the colours are at once seen. An instance is afforded of this in the painting of a Cupid design, which is done entirely on the enamelled surface. As the colour is put on the pieces of the dinner-service, we see how beautifully they harmonise. The bordering of the plates is worked in gold, but the colours—how magnificently they appear! Whilst several artists are finishing the Cupids, which are represented in various fanciful attitudes, their colleagues are at work in painting pleasant touches of English landscape. Flowers of every description are painted with exquisite fidelity to nature, whilst the painting of animals, on which other artists are at work, is no less pleasing. The painting which appears on the glaze has to be burnt in a "muffle," a process which lasts several hours. The colours of themselves contain the necessary chemicals which will give them cohesiveness. Besides this painting, which deals with natural scenery and subjects, there is much conventional decoration. Particular mention should be made of the Montague pattern, the effect of which is extremely lovely, and this is the only word which can be used in connection with it. On a mazarine-blue ground there is worked a festooning of imitation pearls and beads of gold. The border ornamentation is in the nature of turquoise, and the body of the service itself, being egg-shell china, will compare with the finest Sèvres porcelain. Of the cost of this high-class porcelain, some idea may be formed when it is stated that in a special service which the firm made for the Duke of Edinburgh, each plate cost nine guineas. This price is not exceptionally high, and Messrs. Minton's frequently make dinner-services which cost as much as £300 or £400. Above all things, it is satisfactory to know that English makers are holding their own in this fine art industry.

COTTON.—XXIX.

CULTIVATION OF COTTON—PESTS OF THE PLANTATIONS—"PICKING IN"—THE SAW-GIN AND ITS INVENTOR—USES OF COTTON-SEED.

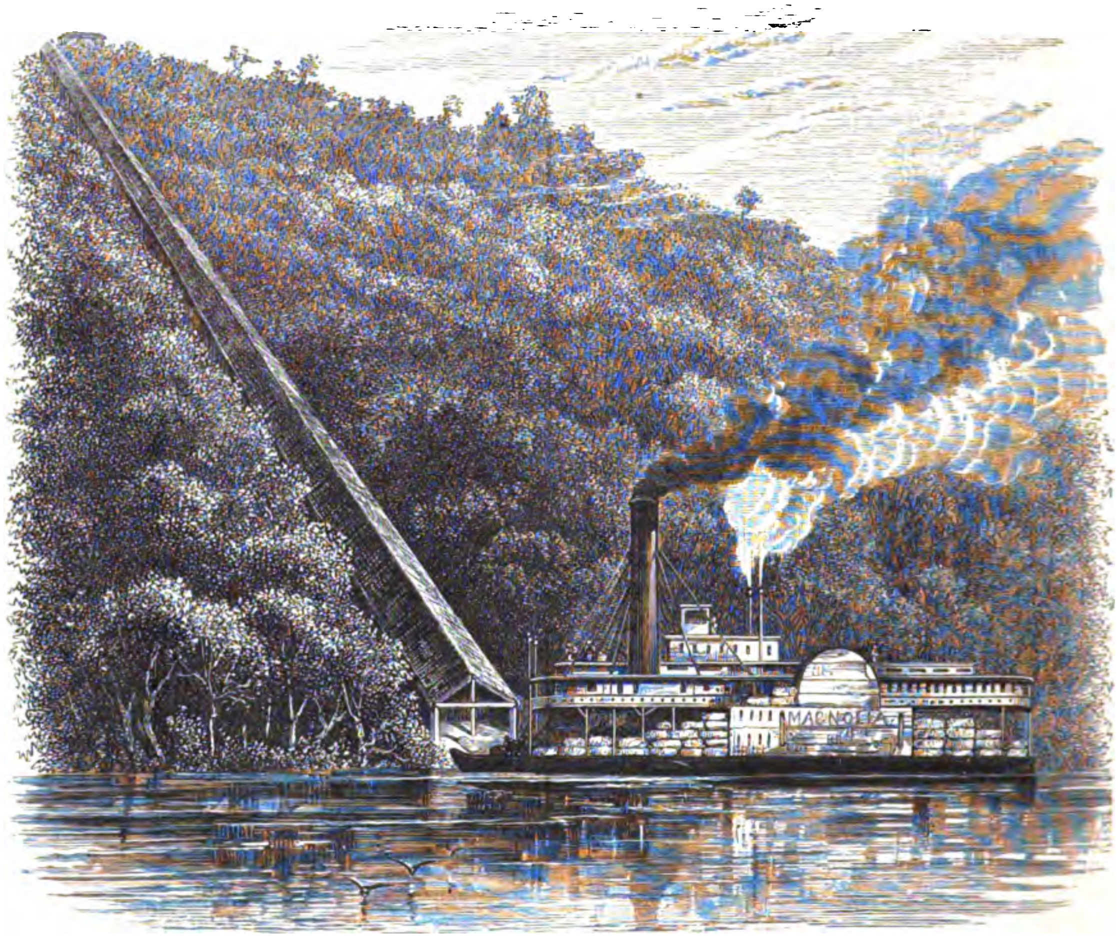
BY DAVID BREMNER, AUTHOR OF "THE INDUSTRIES OF SCOTLAND."

IN the opening chapters of this series some account was given of the cotton-plant, and its history as a source of material for the fabrication of clothing was sketched. The narrative would, however, be incomplete did we not touch upon the cultivation of cotton, and the preliminary preparation of the fibre. Of the common species of *gossypium*, the herbaceous is the most valuable, and that is the variety so extensively cultivated in America, India, China, and elsewhere. A dry sandy soil is essential for the health of the plant, and it thrives where no other valuable crop would grow. Though cotton of good quality is reared in the interior of Brazil and in the upper provinces of Egypt, the best fibre is obtained from plants grown on the sea-coast, and where salt clay mud is available for manure. The famous Sea Island cotton owes its superb qualities to the situation in which it is grown. In the early days of cotton cultivation in America, the farmers tried many experiments before they determined what mode of husbandry yielded the best results. In other countries the operations of the field were conducted in a primitive style, which it was obvious admitted of improvement; and instead of copying what were unmistakably bad systems, the American cotton-farmer at once embarked in the pursuit of something better. It is several years short of a century since the first small parcel of seed from which the Sea Island cotton is produced found its way to Georgia and South Carolina, and the first crop or two demonstrated the suitability of the country to the plant. The fame of the Sea Island fibre soon became known, and a ready market was found for it in England, where the cotton manufacture was undergoing rapid development. The relative value of this variety of cotton is fully maintained to this day, and it is from it that the finer yarns and threads are made.

The first operation in cotton cultivation is to clear the ground of the decayed stalks of the previous crop. This is now done with a machine known as the cotton-brush chopper. The ground is then manured, ploughed, and worked into ridges. Each ridge is about five feet in width, and at certain distances, according to the nature of the soil, ditches are cut across the field to draw off the superfluous surface water. The planting season extends over the months of March and April; but the first half of the latter month is esteemed the best time. Until a comparatively recent period the work of the field was done by hand labour, aided by the spade and hoe only. Now machines have been generally introduced. Under the old system, when the planting time arrived the work-people were disposed in gangs of three. Each gang took in hand a ridge at a time—one opening a small trench along its crest, the second dropping in the seed, and the third closing in the opening with a hoe. Now planting-machines are used which perform the successive operations of opening the drills, dropping in the seed, and covering it up. In the earlier part of the season, when the soil is cold, the drills are made only two inches in depth, but towards the close they are made four inches deep.

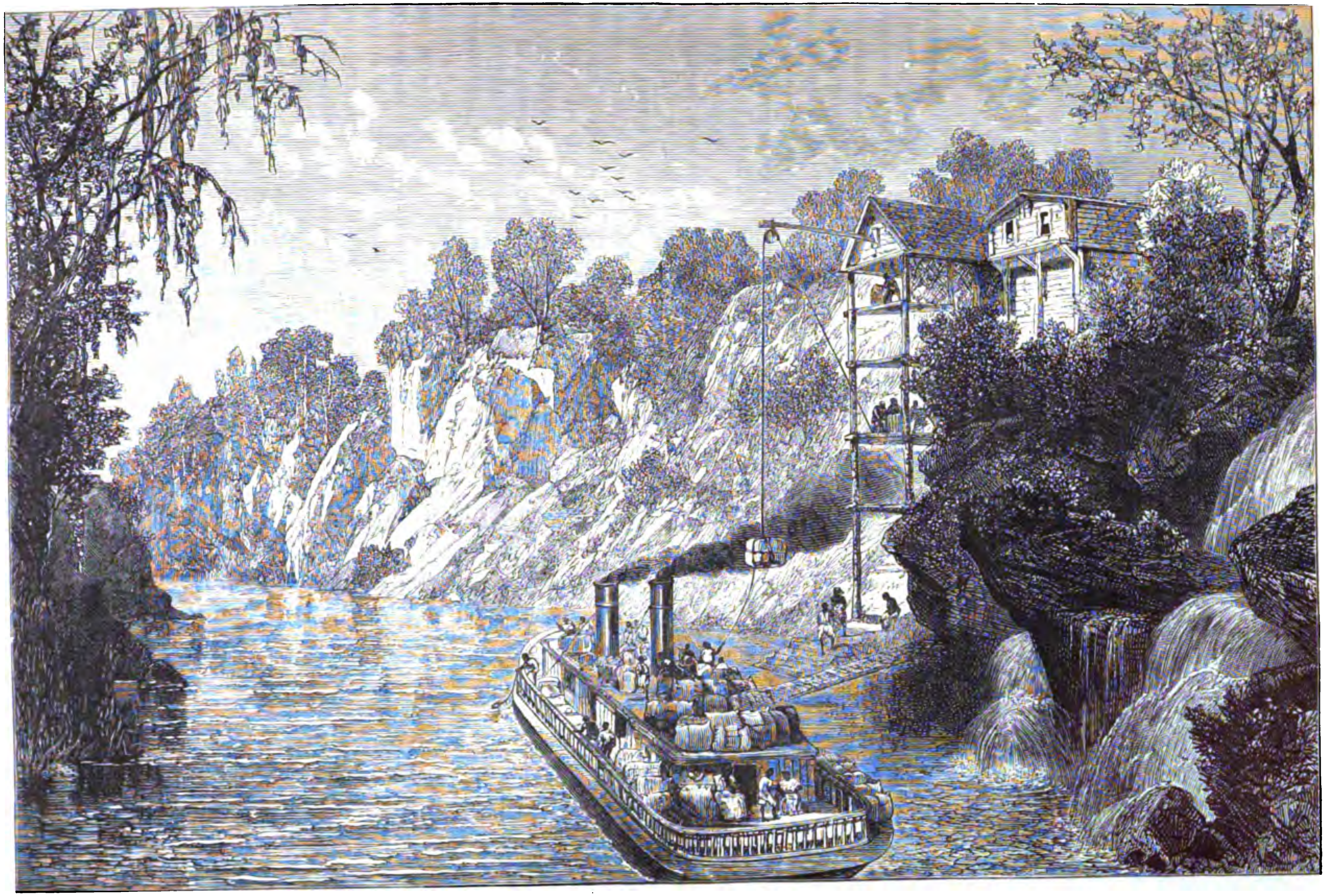
From the moment of putting the seed into the ground till the crop is gathered the farmer is kept in a constant state of anxiety, as there is no certainty that his labours may not be frustrated by one or other of several enemies. A single night's frost, or even a blast of north-east wind, is sufficient to blight the young plants; but even should they escape such a visitation, the cockchafer or cutworm may appear and devastate the fields. When the crop is thus destroyed there is generally time for re-sowing, especially if that can be done within the month of May. Should the plants prosper, they will in a little time have to be thinned, so that those that are retained may have plenty of space in which to develop. The thinning, when done by hand, is performed at several intervals, the weaker plants being removed, and only those of highest promise being left finally to occupy the ground. A thinning-machine, called a cotton-chopper, is used in some parts. It consists of a frame having a series of revolving hoes so arranged as to scoop gaps at convenient intervals in the rows of young plants. After the thinning, no matter how it is done, the earth is heaped round the remaining plants, so as to supply them with fresh nourishment and afford support to their stems. All weeds are removed at the same time. The "working" of the crop is usually completed towards the end of July, by which time the summer rains are looked for, and a fresh source of anxiety presents itself to the

farmer. Should the rain be excessively heavy, it not only beats the plants to the ground, but causes them to shed their fruit. With the August full moon the caterpillar, should it be about, will be certain to make its presence known. It is a most unwelcome visitor, and the extent and rapidity of the havoc it causes are alike remarkable. The caterpillar is the offspring of a small brown moth, resembling the candle-moth, which deposits its eggs upon the leaf of the cotton-plant always a night or two before the full or new moon. The eggs are hatched within a few hours of being deposited. The worms do little harm during the first few days of their existence, but when they reach a certain stage of their growth they become terribly voracious, and in the course of a few hours devour every bit of green over large tracts of country. During the whole period of the cotton-plant's growth the reports from the plantations are eagerly scanned at the American ports, and also at Liverpool and Manchester, and every change of weather or the appearance of any of the pests referred to agitates the market for raw cotton. A feature of the American newspapers during the cotton-growing season are the elaborate reports telegraphed from the plantations, and the speculations based thereon.



A Cotton Shoot.

Should the crop arrive safely at the flowering stage, the fields present a most beautiful appearance. Wide waving groups of viny foliage are blended with three-coloured blossoms of brilliant hues, and pods of darker shades in various states of ripeness. When the flower comes forth it has a fine yellow colour, which it retains during the first day; under the influence of the night air it changes to a red or crimson hue; on the third day it darkens into a chocolate brown, and then falls to the ground, leaving a pod already half an inch in diameter. The interval that now elapses before the fruit arrives at full



Loading a Cotton Steamer. *(From a Sketch by Miss C. C. Hopley.)*

maturity is variable, depending on the weather—in some cases it amounts to only three weeks, and in others to six. Usually the earliest pods open about the 1st of August, and the work of "picking in" begins. This is a tedious process, which can be carried on during fine weather only. The pickers have bags suspended from their necks, and thus equipped they enter the field and look out for the fully-opened pods, from which they pluck the cotton-wool and seeds, and deposit the same in the bags. In the height of the picking season—that is, when the largest proportion of pods are to be found open—a picker will collect an average of about fifty pounds weight of cotton and seed in a day, but at the opening and close of the season ten pounds is about the average. In order to get rid of all moisture, the cotton is spread upon platforms and exposed to the sun for one or more days, as may be necessary.

The next business is to separate the cotton from the seeds which it encloses. To do this by hand would be a very slow process, as one person could not turn out more than one pound weight of clean wool per day. In India, China, and other parts of the East, the separation of the seed and wool has from time immemorial been effected by means of the roller-gin, a machine of the simplest form. It consists of two small rollers of hard wood, made to revolve in opposite directions. The cotton is fed in between the rollers, and while the fibre is drawn through the seeds are forced backward and fall to the floor. One of these machines is capable of cleaning from forty to sixty pounds weight of cotton in a day. A modification of the roller-gin has long been employed by the growers of Sea Island cotton, being retained even after the saw-gin was generally introduced for dealing with the shorter-stapled varieties. The old-fashioned roller-gin was turned by hand, but when it was adopted by the cultivators of Sea Island cotton it was driven by power. The invention of the saw-gin marked an important era in the cotton trade, as it enabled the growers of short-stapled cotton, in which the adhesion of the wool to the seeds is much stronger than in the long-stapled kind, to dress their wool in an expeditious manner and at a cheap rate. The machine was invented by Mr. Eli Whitney, of Westborough, Massachusetts, in the year 1793, and its merits were so manifest that it was at once adopted. Worked by one horse, and attended by one man, a small saw-gin is capable of separating over six hundred pounds weight of cotton per day. It is rather rough on the fibre, and makes a higher percentage of loss of material than the apparatus used for dealing with Sea Island cotton, but its efficacy of action otherwise more than compensates for this. The introduction of the saw-gin gave an immense impetus to the cultivation of short-stapled cotton.

Mr. Whitney's experience was not unlike that of nearly every one of the inventors of cotton machinery in this country. We shall relate his story in the words of Dr. Ure:—"Having spent a winter in completing his machine, Mr. Whitney showed a few friends that it could separate more cotton from the seed in one day by the labour of one man than could be done by the existing methods in a month. The construction of this instrument was an event of such consequence as to excite a universal interest in the State of Georgia, where Mr. Whitney lived in narrow circumstances under the roof of a hospitable friend. Neither the sentinels of justice nor the fear of the law could restrain the eager crowds from breaking into his workshop by night, and carrying off his wonder-working tool. In this dishonourable way the public acquired possession of Mr. Whitney's invention before the model was finished to his mind, and before he could secure the protection of a patent. Many copies were immediately made from it, with slight variations, in order to evade the patent, which he obtained soon thereafter. Thus the inventor of a most ingenious machine was not suffered to reap in peace a reasonable share of the fruits of his labours, which proved so beneficial to his country. He was tormented with the most vexatious litigations, and though he was soon supported by a partner possessed of some capital, he was in a few years well-nigh ruined. At length, in the year 1801, the Legislature of South Carolina purchased from Mr. Whitney a patent licence for that State, for the sum of 5,000 dollars. Next year he disposed of a licence to the State of North Carolina, the Legislature of which laid a tax for five years of 2s. 6d. upon every saw in every gin that was mounted within their jurisdiction. Some of these gins contained no fewer than forty saws. This tax was collected, along with the public imposts, by the sheriffs, and after the expenses of collection were deducted the balance was faithfully paid over into the hands of the patentee. No small portion of the funds thus honourably raised in the two Carolinas was expended in carrying on fruitless lawsuits against the piratical invaders of his privilege in the State of Georgia. 'There have indeed,' says the American biographer, 'been but few instances where the author of such inestimable advantages to a whole country as those which accrued from the invention of the saw-gin to the

Southern States was so harshly treated and so inadequately compensated as Mr. Whitney. He did not exaggerate when he said that it raised the value of those States from 50 to 100 per cent.' 'If we should assert,' said Judge Johnson, 'that the benefits of this invention exceed 100,000,000 dollars, we can prove the assertion by correct calculation.' Whitney had to vindicate not merely his pecuniary rights, but his character, for attempts were made, as is usual in such cases, to deprive him of the honour of the invention. In 1812 he applied to Congress for a renewal of his patent, representing that he had been tormented with litigation for eleven years before his rights were legally recognised, and that thirteen years out of the fourteen of his privilege had expired with very little advantage to himself, but very beneficially to the nation, 'for his invention had enabled one man to do the work of one thousand.' The planters of the Southern States so warmly opposed Mr. Whitney's application that it failed of success. Meanwhile this ingenious man, when he found his hopes blasted of reaping the fair reward of his saw-gin, betook himself to the manufacture of fire-arms, and executed several contracts for supplying the United States service with them. Thus the implements of human destruction enabled him to realise that competency which one of the most powerful tools of peaceful industry had failed to procure."

The saw-gin is an exceedingly simple machine. It consists of a stout wood frame, three or four feet square. Across one end of it extends the hopper, a narrow box, one side of which is composed of a grating of stout wires arranged perpendicularly. Parallel to this grid is the saw-roller, an axle of wood, on which a series of circular saws, ten inches in diameter, is mounted, the space between the saws being about an inch. The roller is so mounted that the saws pass through the grating a little way, and so reach the cotton in the hopper. When the machine is in motion the saw-teeth catch the filaments of cotton and drag them through the grid, the openings in which are too small to allow the seed to pass. Behind the saw-roller is a cylinder of larger diameter, which has on its surface a number of brushes corresponding to the saws. This cylinder moves at a higher rate of speed than the saw-roller, and brushes the fibres from the teeth of the saws, throwing them into a receptacle beneath. The seeds, when stripped of the coating of fibre, fall through a grating in the bottom of the hopper into a separate compartment. Several attempts, more or less successful, have been made to improve the saw-gin, and machines on a different principle have been introduced. Of these we may mention the Macarthy gin, which differs from the saw-gin mainly in having, in place of the saws, a roller covered longitudinally at intervals with fillets of leather arranged spirally. While the fibre is being drawn through the grid by the leathers the seeds outside are knocked off by a vibrating knife which extends across the machine. This machine inflicts less injury on the cotton than the saw-gin, but it is not so expeditious in its action, nor is it so easily kept in order by the unskilled hands to whom its working has to be entrusted on the plantations. The lock-jaw, or Cowper's gin, differs from those named in having an intermittent action. The cotton is fed into a hopper extending across the machine, and is gently pressed towards a blunt knife-blade which lies across the machine, immediately over a roller covered with strips of leather arranged longitudinally. This blade is raised slightly, so as to allow the protruding fibres to get between it and the roller. It then descends, and the cotton is nipped between it and the roller, while at the same time a comb or beater drags the seed backward into the hopper. The grip is then relaxed, and the roller makes a partial turn, carrying with it the detached cotton, and deposits it in a receptacle beneath. A fresh bite is taken, and so on. The machine deals very tenderly with the fibre, but its slowness of action detracts from its value, and it is, besides, too complicated in its parts to be understood and kept in repair by the work-people.

Until a comparatively recent time, the cotton-seed not required for sowing was employed only as manure. Modern science has, however, found other uses for it, and it is now a commodity of considerable commercial value. In the United States alone the seed of an average crop will weigh nearly two and a half million tons, and if half of this be allowed for seed and waste, a vast quantity, it will be seen, is left for other purposes. The first process in turning the seed to account is to remove from it the short fibres which the first ginning has left adherent to it. Though unfit for spinning, these fibres are of considerable value as a material for making paper. They are removed by repeated ginning, and then the seed is ready for the decorticator, or huller, a machine which crushes the husk and sets the kernel free. The husks and kernels are separated by sifting. The former are thrown into heaps and left to decompose, and are ultimately used as manure. The kernels are taken to the

crushing-mill, and there ground into a meal of a yellowish-green colour. This meal is now placed into steam-heated tanks, and after a few minutes it is found that the oil-vessels have been opened and the fluid set free. From the tanks the meal is filled into sacks, and in these subjected to the action of an hydraulic press, which squeezes out the oil, and causes it to flow into a tank, where it is allowed to settle for a certain time. For the purpose of clarifying the fluid, oil of vitriol is added to it and allowed to act for eight hours, during which time the fluid is kept in agitation. The acid is then drawn off, and the oil is subjected to the action of steam at 20lbs. pressure for several hours. This completes the clarifying process, and the oil is ready for the market. It is used in lamps and as a lubricant, and is also suitable for mixing with paint. In a purified state it is applied to many other purposes. There is still one portion of the product of the seed to deal with—namely, that which remains in the press-bags. This, under the effect of the pressure, is found to be formed into compact slabs. These are removed from the bags, and after being dried are sold as cattle food. A considerable quantity of cotton-seed is imported into England by oil manufacturers.

How the cotton-wool is baled, sampled, sold, and stored on board ship will be learned from the concise description of those various operations contained in the following "Memorandum of the mode of preparing Cotton for market in Louisiana, and of selling and shipping it at New Orleans," read at the International Cotton Convention held at Liverpool in 1877:—

"Cotton, separated from the seed by the gin, is taken off the latter by brushes revolving at great speed, and thrown by them into the lint-room, where it falls on the floor in a round heap; the lighter and cleaner portion in the centre and further part of the pile, the more leafy and heavy part gravitating to the edges of the heap, and dropping nearer the brushes. The attendants who carry the cotton to the press fill their baskets out of any portion of the heap, thus causing the inequality of cleanliness in the bale with which we are all familiar. As a general thing, an expert in cotton can, if he be hostile, produce from any bale, from low middling down, two different grades of cleanliness. As dust and flour accumulate on the beams, in corners of the lint-room, or at the mouth of the gin, they tumble off into the pile of cotton beneath, and form 'gin fall.'

"The press consists of a box about 4½ ft. long, 2 ft. wide, and 10 ft. high, with a heavy screw, to the bottom of which is attached the top of the box. As the cotton is thrown into the latter from baskets, a man tramps it down until the box can hold no more, the pressure of the screw is applied, and the bale is formed about 3 to 3½ ft. high. At New Orleans the cotton is hauled to a compressing establishment, which consists of a compress of great power. A large open yard is attached, giving ample room for ranging the bales for the purposes of sampling, classing, &c. The yards are surrounded on all sides by sheds for storing. The factor, to whom the consignment is made, has the cotton sampled; it is then stored away in the sheds till the parties wish to sell it.

"When about to sell, the factor puts the proper classification on each sample he is about to offer, and records in his classification book the mark of the bale, the owner's name, and the quality. The samples are then placed upon a table, which, when covered, presents an unbroken surface of cotton, the better classes at one end, and grading down to the poorest at the other. A full table contains 200 to 300 samples, and may embrace cotton from perhaps 50 to 100 plantations. The papers which contained the samples are doubled up and placed under them, for the purpose of identification afterwards. After the sale the samples are rolled up, and remain in the hands of the vendors, and it is creditable to the trade of New Orleans that the instances are rare indeed in which the purchaser thinks it needful to refer to these samples, and still more rare when there is the slightest suspicion of their having meantime been tampered with. The seller obtaining a round price for so many different grades, refers to his classification book, and gives to each bale such value as will make the whole fetch out the average price he obtained; the purchaser in like manner must divide out the cotton, as it is classed in the yards, as it suits his different orders, and place on each sub-division its proportionate cost, so as to fetch out the price paid. Occasionally large crops are offered, but on the average of the trade for the season, perhaps three or four bales might be taken as representing the size of lots sold.

"For delivery the cotton is taken out of the storage sheds and ranged in the open yard, a pathway being left between each double row, so that each bale is accessible; great care is exercised in placing the fair side of the bale uppermost for sampling, otherwise the cotton drawn out in a different rotation from that in which it was put

into the bale comes ragged and broken, and is not a fair exhibit of the quality. The purchaser having sampled, classed, weighed, and ship-marked each bale, the cotton is taken to the compress, where it is subjected to great pressure between two flat surfaces and reduced in height to less than two feet; this process is paid for by the ship. During its progress all bands save one are removed, and the purchaser avails himself of this opportunity to examine for false packing, the open state of the bale greatly facilitating the operation.

"Cottons are bought and sold by the gross weight, no tare being allowed. The lessened length of the bands caused by reduction of the circumference in compressing is equal to 2½lbs. per bale. Our Cotton Exchange levies 5 cents per bale upon the receiver of cotton; the funds derived from this source are devoted exclusively to the payment of supervisors, one of whom, under the authority and control of the Exchange, is located in each press yard, and weighs all samples and loose cotton removed from it, limiting each sample to 6 ounces. This arrangement has effectually arrested the pilfering of cotton, which previously had been a source of serious loss. Our Exchange also taxes shippers 2 cents per bale, which has been found sufficient to defray the expenses of a staff of inspectors, who put a stop to pilfering in the streets and levies, and carefully watch that cotton on the wharf in course of shipment is protected from injury, from the weather, or from carelessness in handling, the fertile sources hitherto of complaints and litigation as to country damage.

"Much yet remains to be done to improve the system of storing on shipboard. At present the cotton is forced into its place with jack-screws; if a bale happens to be much longer than its fellows, the portion projecting above the row is cut off, or part of a bale is removed to make place for a beam. On arrival at Liverpool each row must be broken out by the use of hooks and a winch, and the whole cotton is delivered in a wretched condition, with much loss and waste. Several new and very powerful compresses are being erected at New Orleans; it is to be hoped they will render the use of the jack-screw less needful."

INDUSTRIAL LEGISLATION.—XIII.

THE RECOMMENDATIONS OF THE CHILDREN'S EMPLOYMENT COMMISSION OF 1863—EXTENSION OF THE ACT TO VARIOUS BRANCHES OF MANUFACTURE—HARDSHIPS OF SEMPSTRESSES AND DRESSMAKERS—FACTORY AND WORKSHOPS ACTS OF 1867—MR. MUNDELLA'S BILL—FACTORY ACT OF 1874—FINAL CONSOLIDATION OF THE FACTORY ACTS BY SIR RICHARD CROSS IN 1878.

BY JAMES HENDERSON, ONE OF H.M. SUPERINTENDING INSPECTORS OF FACTORIES.

SO conclusive were the recommendations made by the Children's Employment Commission in their first report, published in 1863, that a Bill was at once drafted, and introduced during the Session of 1864, which placed the following manufactures and employments under legislative restriction:—The manufacture of earthenware, except bricks and tiles, not being ornamental tiles; the manufacture of lucifer matches; the manufacture of percussion caps; the manufacture of cartridges; the employment of paper staining; the employment of fustian cutting.

The Commissioners in their report estimated that 17,776 children and young persons would thus be placed under the protection, and be benefited by the privileges, of the Factory Act. The Bill passed through both Houses of Parliament with very little difficulty. Petitions were presented in favour of it signed both by employers and work-people, more particularly from the Pottery districts of Staffordshire.

Probably there was no occupation named in the Factory Act of 1864 in which some regulation or restriction was more necessary than in that of fustian cutting. Children of very tender years were at times employed, and the labour was most severe, and frequently long protracted. Mr. Redgrave, H.M. chief Inspector of Factories, in his report for January, 1865, gives the following description of the work done by a child in fustian cutting:— "Each piece of velvet contains nine hundred inches of pile in width, and the knife has consequently to make nine hundred cuts from end to end of the frame on each length of the fustian;

and as nine lengths are considered a day's work, it follows that the knife is passed daily over a space of about ten miles, and the child has to make 8,100 passes of the knife, or, reckoning the child worked ten hours and a half per day, and allowing half-an-hour for intervals of the fustian cutting, sharpening the knife, and adjusting the lengths of fustian upon the table, it would cut thirteen inches per minute, thrusting the body forwards and backwards the same number of times."

The effects of this very severe labour on young children were made evident by their stunted growth and deformed limbs. The new Act forbade the employment of children under eleven years of age at this occupation, and enforced half-time attendance at school up to the age of thirteen.

Mr. Robert Baker, H.M. Inspector of Factories for the Staffordshire district, gave a very interesting, but at the same time most distressing, description of the social life and habits of the operatives in the Pottery districts. Drunkenness and dissipation were periodically indulged in, the workmen trusting to make up for the time wasted in this way by working long and irregular hours. The restriction placed upon this by the Factory Act exercised a marked influence in a very short space of time, to the great advantage both of the health and the morals of the whole population. Mr. Robert Baker in a subsequent report quotes some remarkable testimony respecting the great value of the Act both to employers and to work-people. Mr. Campbell, of the well-known firm of Minton and Co., acknowledged to the inspector of the district that after the Act was applied to their establishment, "the quality of their ware had been improved, and that they had less spoiled ware since the greater regularity of work had put a stop to hurried production." The almost universal experience seemed to be that workmen could produce quite as much on an average under the restricted hours of the Act as they did when working irregularly, and for longer hours.

The very success of the Factory Act of 1864, however, made the contrast greater between the condition of the work-people employed in occupations regulated by law and others which were not, and strengthened the arguments made use of for still further extending the application of the Factory Acts. In some districts, indeed, the anomaly of having one trade restricted and another non-restricted led to serious inconvenience. Writing in October, 1865, Mr. Redgrave alludes to this difficulty, which was found to press with special severity upon young children. Under the Act of 1864, it was anticipated that there would be a large increase in the number of children sent to school, but instead of this proving to be the case, it was found that they were simply withdrawn from the occupations which were regulated and employed in others which were altogether free. Very naturally this state of things produced many complaints. Employers found themselves deprived of the help of children and young persons, who preferred to go to factories in which no restriction was placed upon their labour. An earthenware manufacturer thus states his case to Mr. Redgrave, and it must be owned he had a substantial grievance. Speaking of the Act of 1864, he says, "by its adoption I have suffered greatly, not having more than two-thirds of the work I did before its adoption; and I am at present nearly at a stand-still, because men will not do the work that was formerly done by juveniles, and the very children that the law wisely prohibits us from employing are taken by the glass works and iron foundries, whose employments are at irregular hours both day and night, and far more detrimental to health and morality than the earthenware trade; and on these grounds it seems, and really is, a great hardship and an injustice to us."

About this period the Royal Commissioners on the employment of children and young persons made their second report, which proved a most elaborate and interesting document. It embraced reports from the Assistant Commissioners on the lace manufacture, the hosiery manufacture, straw-plait making and making up, milliners, dress-makers, sempstresses of all kinds, boot and shoe-makers, glove-makers, &c. It was estimated that nearly one million persons were employed in these occupations, the majority of them being women and young persons. Some of the evidence collected disclosed a most distressing state of things among the work-people. Long hours and ill-ventilated and over-crowded workrooms were much complained of. The description given of some of the West End dress-making establishments in London was deplorable. Evidence was adduced to the effect that young women were kept standing "day after day for weeks, at trimming the trains or ball-dresses till they got very ill; their legs swelled and their feet blistered." In some cases the bed-rooms were described as "shocking." "In the height of the season, three sleep in a bed; one bedroom was so damp that the water would run down the walls," and in another house, the bed-rooms are described as "very close and wretched."

After mature consideration, the Commissioners came to the conclusion that there was nothing in the occupations which the Assistant Commissioners had investigated which would be incompatible with their regulation under the Factory Acts. In this opinion they were sustained, it is satisfactory to know, by a large number of employers, who avowed that they would willingly submit to the slight inconvenience to which they would be subjected, in order that the whole trade might be regulated.

Four subsequent reports were issued by the Royal Commissioners, who concluded their labours in 1866. The third report dealt with the miscellaneous metal manufactures of the United Kingdom; the fourth, with the paper, glass, tobacco, India-rubber, and other miscellaneous manufactures; and the fifth, with letter-press printers, bookbinders, and stationery manufacturers. The sixth report was devoted to the discussion of the state of children employed in agriculture in gangs, but it is unnecessary for us to follow their inquiries into this distinct and separate field.

The Commissioners found no difficulty in coming to the conclusion that all the trades and occupations enumerated should be regulated by law, and that the existing Factory Acts, with certain modifications, which in some cases they suggested, should be extended to them all. The total number of persons employed in these miscellaneous manufactures and occupations, it was estimated would approach one million and a half. Almost as soon as the fifth report of the Commissioners was published, bills were prepared by the government of the day which practically covered all their suggestions. They took the shape during the following session of the Factory Acts Extension Act, 1867, and the Workshops Regulation Act, 1867. But little opposition was offered to either of them. The government gave a fair consideration to the special claims urged by particular trades for modifications and special relaxations. The consideration and adjustment of these gave the heads of the Factory Department much trouble and anxiety, but the success which attended the administration of the new Act showed that it was not labour in vain.

By the Factory and Workshops Regulation Acts of 1867, the whole of the manufacturing industries of the country were practically placed under legal restriction and regulation. The direct supervision of the Inspectors of Factories was limited for a time to the establishments defined as Factories, the enforcement of the Workshops Act being entrusted to the local authorities. This arrangement, however, did not prove satisfactory. Different "local authorities" took different views of their duties in enforcing this new law, some applying it with stringency, and others wholly neglecting it. This difficulty was dealt with by a short amending Act, passed in 1871, by which the local authorities were superseded by the Inspectors and Sub-inspectors of Factories. In the preceding session (1870) a short Act also was passed, which had for its object the repeal of the old Print Works Regulation Act, and the placing of these establishments under the same regulations in respect to the employment of children and young persons as were enforced in other Factories. Certain special modifications were given to meet particular exigencies in the trade, which experience had proved were unavoidable.

The next important step in Factory Legislation was taken in 1874, when an Act was passed still further limiting the hours of work for women, young persons and children. It was the result of an agitation, which had been persistently maintained for several years in the textile manufacturing districts, for a nine hours bill. The unexampled expansion in the trade and manufacturing industries of the country, which was experienced during the four or five years preceding 1874, had brought about some singular results. The hours of work in those branches of manufacture which were least affected by the Factory Acts, had become shorter than in the textile factories. In the building trades, in all the various branches of the iron manufacture, fifty-four hours had come to be accepted as a maximum for a week's work, and in some cases it fell so low as fifty-one and even forty-eight. This was in striking contrast to the sixty hours, authorised by the Factory Act, and which was still insisted upon in the textile manufacturing districts. The supporters of a nine hours Factory Bill found an able advocate in the person of Mr. Mundella, M.P., who soon identified himself in the House of Commons with the movement. The influence of an extended suffrage also made itself felt in the discussion of a question in which it was supposed the working classes were deeply interested. Neither of our great political parties could afford to evade the question, and Mr. Mundella soon experienced the strength of this influence. Lord Aberdare, when Home Secretary under Mr. Gladstone's administration, appointed a medical commission, consisting of Dr. Brydges of the Local Government Board, and Mr. Holmes, the Surgeon to the London Police Force, to make an

inquiry into the allegations of those who advocated the nine hours Bill. The result was an interesting report which was presented to Parliament, and which furnished most conclusive evidence of the great success which had attended the enforcement of the Factory Acts, and of their important influence on the health and morals of the population. The picture drawn of the condition of the operative classes in the textile manufacturing districts in this report, was in marked contrast to that portrayed in the official reports which had preceded the first Factory Acts, and it illustrated the wonderful improvements which had taken place in social life during the interval. The report recommended that a further restriction should be placed upon the working hours of women, young persons and children, but it was felt by many that the evidence adduced by Drs. Brydges and Holmes failed to support that conclusion, at least so far as adult women were concerned.

The Parliament of 1874 had no sooner met than Mr. Mundella re-introduced his nine hours Bill; but the new Government were not long in superseding him—Mr. (afterwards Sir) Richard Cross, the Home Secretary, intimating it was their intention to deal with the subject. This pledge was fulfilled by the introduction of a Bill which passed into law, and came to be known as the Factory Act of 1874. The preamble of the Bill set forth that its object was to improve the health of women, young persons, and children employed in manufactures, and the education of such children. In effect the Government adopted Mr. Mundella's proposals so far as the improvement of education was concerned, but suggested a compromise in respect of the limitation proposed upon the hours of work for adult women and young persons. Whereas Mr. Mundella's Bill fixed a maximum of fifty-four hours as a week's work, the Government Bill suggested fifty-seven instead of sixty. Mr. Cross, in fact, practically split the difference between those who supported and those who opposed Mr. Mundella's proposal, and had little difficulty in passing his Bill through Parliament. This last restriction on the hours of work of adult women gave rise to much dissatisfaction among employers of labour, who maintained that its necessity from a sanitary point of view was never clearly established. The great reaction which took place in the industrial prosperity of the country subsequent to the Act of 1874, lent a point and force to their complaints which they would otherwise not have had.

The next important stage in the history of industrial legislation in this country was the appointment, in the year 1875, of a Royal Commission to inquire into the working of the Factory and Workshops Regulation Acts, with a view to their consolidation and amendment; and specially to consider whether they could be made more consistent and harmonious, and whether any of their provisions might be extended to other trades, industries, and occupations not included therein. This Commission, as the result proved, was most wisely and judiciously constituted. Its chairman was Sir James Fergusson, and his colleagues were Lord Frederick Cavendish, Lord Balfour of Burleigh, Sir Charles Du Cane, Mr. Henry R. Brand, Mr. Thomas Knowles, and The O'Conor Don. The report which this Commission presented to Parliament was a most exhaustive and satisfactory document, and furnished conclusive proof of the success which had attended the working of the Factory Acts in the United Kingdom. The Commission made several valuable recommendations. They suggested that the various Factory and Workshops Acts should be consolidated, and that places where employment "in the open air" was carried on and bakehouses should be included within the scope of inspection. Practically the Commission approved of the existing regulations applying to factories and workshops, and the alterations they suggested were mainly directed to the establishment of greater uniformity. The Commissioners were not quite unanimous in respect to all their recommendations: Mr. Knowles dissented from some of the clauses relating to the Mines Regulation Act, and The O'Conor Don, in a separate report, discussed with much ability the general question of the advisability of imposing such stringent restrictions on the hours of work of adult women.

The Commission having thus so satisfactorily concluded its labours, nothing remained to be done but to give effect to them, and a Bill was shortly afterwards introduced into the House of Commons by Mr. Cross which had this for its object. The preparation of such a measure necessarily involved an immense amount of trouble and of labour, but fortunately the subject was one to which H.M. Chief Inspector, Mr. Alexander Redgrave, C.B., had long devoted his attention. In Mr. Cross, the Home Secretary, the Bill found a most competent and able exponent in the House of Commons; and it was ultimately passed, with the general approval of both branches of the Legislature, in the session of 1878.

The whole of the existing regulations affecting employment in factories and workshops of every class are embodied now in one intelligible Act of Parliament, and the experience of its operation so far has been entirely favourable to it. The Act of 1878 constituted a most satisfactory and successful termination to nearly eighty years' discussion and agitation on the question of factory legislation. The unanimity with which its provisions are now accepted, and the loyalty with which they are acted upon by every class in the community, constitute the most triumphant justification of those benevolent and philanthropic men who advocated the cause of the oppressed factory children, when that cause had comparatively few friends and supporters in the country.

SHIP BUILDING.—XXIX.

METHODS OF LAUNCHING.

AMONG the subjects requiring careful consideration before the building of a ship is begun, one of the most important is the arrangement of a method by which she shall be set afloat successfully when her construction is completed. Unlike Robinson Crusoe, who could not launch his boat after he had built it, the prudent ship-builder decides how each vessel shall be launched or floated before he lays the "blocks" upon which she is to be built, or prepares the various pieces of the keel. Want of precaution and forethought may lead to disaster. The ground requires to be prepared for bearing the weight of the structure to be placed upon it, both while the work proceeds, and when the launch is taking place. If, as is most common, the ship is built upon a sloping "slip" on the bank of some river or on the sea-shore, it is needful to take account of the declivity required for launching her in laying the blocks, to make allowance for the rise and fall of tide, and to provide for checking or controlling her motion if she has to be launched into a narrow stream. Although the mode of launching may remain the same in principle, its details have to be modified to suit varying conditions. On the broad waters of the Hamoaze or Milford Haven a ship can be allowed to glide freely down the "ways" with gradually accelerated motion; and, entering the sea with great velocity, to move out from the shore until the fluid resistance brings her to rest. On the Clyde or in Blackwall Creek the conditions are entirely different; the stream is narrow, and a long ship must have her motion checked as soon as she is afloat. As a mere spectacle the former launch may be preferred; yet the latter displays even more forcibly the triumph of mechanical skill and foresight, and illustrates the possibility of preventing many of the accidents that take place when the operations of launching are carelessly conducted. In proportion to the number of ships launched these accidents are few; but they might be made still less frequent, and considerable loss of money as well as risk of life would thus be avoided. Some ships have stopped when partly launched; others have launched themselves before the proper time had arrived; others have fallen over on their sides before they had reached the water, or in many other ways have caused injury to themselves or to the workmen. The causes of such accidents are not always ascertained, but not a few are traceable to the neglect of some precaution, or the desire to economise in arranging the launch. Even when no expense has been spared or precaution omitted, the launch of a large ship necessarily causes much anxiety to the builder, and its successful completion must be a source of satisfaction. It need scarcely be remarked that with decrease in the sizes of ships less elaborate preparations suffice; so that for descriptive purposes it is desirable to take a very heavy ship. An excellent example is found in the case of the *Kaiser*, armoured frigate, built by Messrs. Samuda at Poplar a few years ago for the German Government. Mr. Samuda has published a detailed description of the launch, and from this we borrow most of the following particulars, as well as the illustrations. Fig. 1 shows the *Kaiser* in her launching "cradle;" Fig. 2 shows a cross section at the middle of the length; Fig. 3 shows an enlarged view of the bow, with certain important details of the launch.

It has already been remarked that the slip upon which a very heavy ship is to be built requires to be prepared for the weight to be sustained by it, both during the many months the work proceeds and when the launch takes place. In Fig. 2 the preparations made for the *Kaiser* are indicated:

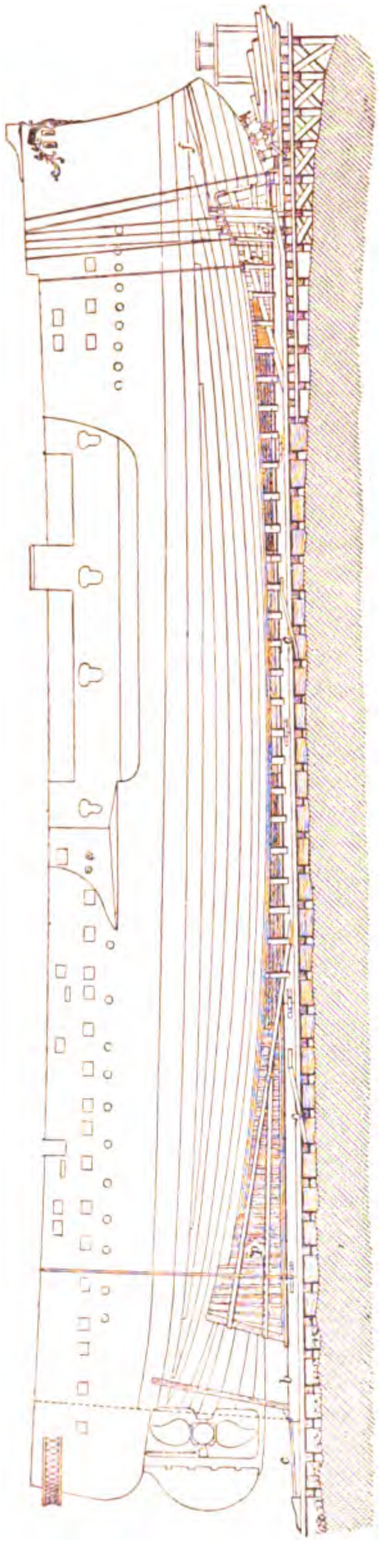


Fig. 1.—The "Kaiser" in her Launching Cradle.

timber piles, in three groups, being driven down into the gravel, directly below the keel, where the blocks are situated, and on either side under the "launching-ways." No less than 400 piles were driven, being distributed at regular intervals along the length of the slip. At the time of launching the *Kaiser* weighed 3,500 tons; this weight was carried during the progress of the work by the blocks, by "buttresses" (such as *h h*, Fig. 2) placed under the bilges, and by numerous timber shores or struts. The blocks consist simply of piles of timber, spaced seven feet apart, at right angles to the keel, the tops of the blocks lying in a plane inclined to the horizon about nine-sixteenths of an inch in each foot. In order to launch this great ship it was necessary, therefore, to transfer 3,500 tons weight from the blocks and other supports on to a "cradle," which should be capable of carrying the vessel while she slid down the launching-ways into the water.

First, let us glance at the "launching-ways," marked *a a* in the drawings. They are two in number, the transverse distance between them in the case of the *Kaiser* being about one-fourth of the extreme breadth of the ship, although frequently the corresponding distance is as much as one-third of the breadth. The upper surfaces are inclined to the horizon three-quarters of an inch to a foot in the case illustrated in Fig. 1; very often a greater inclination (reaching even to one inch in a foot) is adopted. These upper surfaces are carefully planked, the planks resting upon strong timbers, which in their turn are supported by the piled floor of the slip-way. The surfaces are not true planes, but have a slight longitudinal curvature, or "camber," in the case illustrated by Fig. 1; but not unfrequently no camber is used. The lengths of the launching-ways require to be carefully determined with reference to the rise of tide and draught of water of the ship, so that the stern may be fairly floated before the bow ceases to be supported by the ways. It will be noted also in Fig. 2 that on the outer edges of the launching-ways longitudinal "ribband-pieces" (*r r*) are fitted and supported by transverse shores; the object of this addition will be explained hereafter.

Next, attention must be turned to the "cradle" in which the ship is carried. This consists of the bilge-ways (*b b*), which rest upon the launching-ways; of the "stopping-up" (*s*), which fills the space between the upper sides of the bilge-ways and the bottom of the ship for about one-half the length; and of the system of shores at the bow and stern, termed "poppets" (*p p*), which heel upon planks worked above the bilge-ways, and have their heads secured under the bottom. It will be seen that the stopping-up and the poppets fulfil similar duties at different parts of the length, enabling a strong and rigid support to be built from the ship to the bilge-ways. Considerable care and labour have to be bestowed upon the fitting of all these pieces, and their combination into a structure that will remain unchanged in form while it carries the ship down the slope of the launching-ways. Not long before the time fixed for the launch, the cradle is taken to pieces

and the bilge-ways are "turned out," in order that their surfaces and the surfaces of the launching-ways may be well lubricated with tallow or other greasy materials. Upon the efficiency of this lubrication, and the consequent reduction of friction between the surfaces, much of the success of a launch depends. It is also necessary to proportion carefully the bearing surface of the bilge-ways to the weight of the ship. In the case of the *Kaiser* the total area of the bilge-way surface was no less than 1,600 square feet, so that little more than two tons weight had to be carried by each square foot. Experience shows it to be desirable not to exceed three tons per square foot of bilge-way surface with the inclinations of launching-ways usually adopted.

After the greasing of the bearing surfaces has been completed the bilge-ways are replaced upon the launching-ways, and the cradle re-erected and secured in place. The next step, taken immediately before the launch, is to transfer the weight of the ship to the ways from the blocks, buttresses, &c. This is done by "setting up" the vessel, numerous wedges (*w w*, Fig. 2) being driven into the joints between the stopping-up and the upper surfaces of the bilge-ways. The pressure on the blocks is then relieved sufficiently to enable them to be removed from under the keel; and all except a few of the blocks near the bow are so removed as the tide permits before the time fixed for the launch. When this is accomplished and the ship rests upon the launching-ways, there will obviously be a tendency of the bilge-ways to slide downwards; to resist this tendency several temporary shores (*c c c*, Fig. 1) are fitted, and gradually removed as the tide rises immediately before the launch. At the last the bilge-ways are kept from sliding only by the "dog-shores" (*d*, Figs. 1 and 3) placed near the bow.

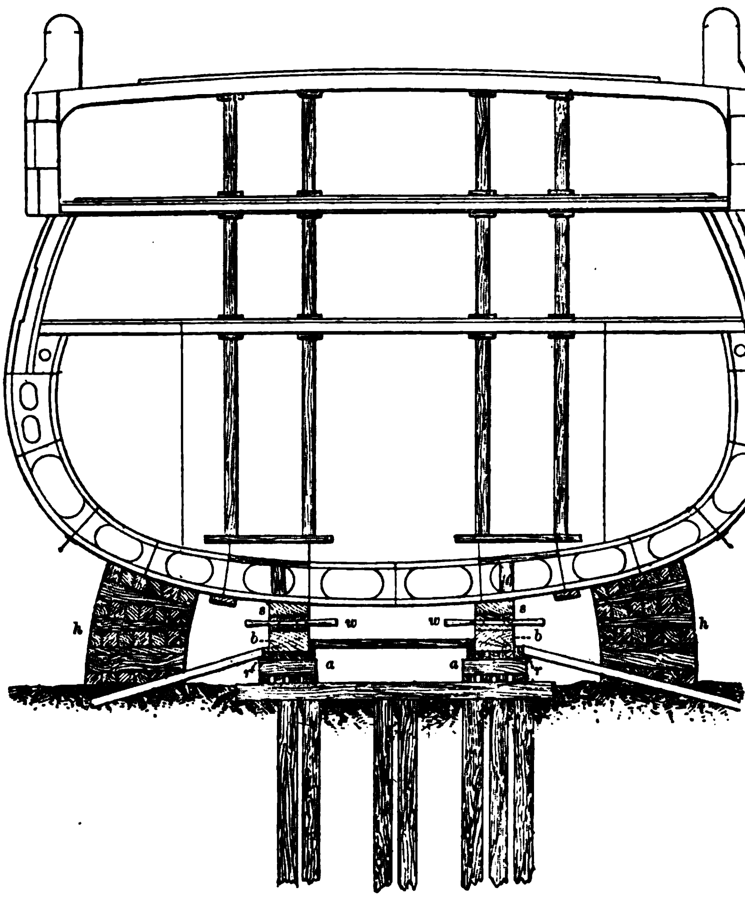


Fig. 2.—Cross Section of the "Kaiser" at Middle of her Length.

The after ends of the dog-shores abut against pieces strongly bolted to the launching-ways; their fore-ends bear against cleats (*e* Fig. 3) attached to the bilge-ways. When the lady who performs the ceremony of launching cuts the cord (*f*) two heavy weights (*g*) are let fall upon the dog-shores, which are driven down below the cleats (*e*). The bilge-ways are then free to move.

"And see! she stirs,
She starts, she moves, she seems to feel
The thrill of life along her keel;
And spurning with her foot the ground,
With one exulting joyous bound
She leaps into the ocean's arms."

Such is the picture which Longfellow has drawn of a successful launch; and if it somewhat exceeds the sober fact, it indicates the excitement and emotion with which such a spectacle is witnessed even by those to whom a launch is no novelty.

All launches are not equally successful. Sometimes a ship requires to be started by the action of

powerful presses, even after the dog-shores are down. At others the exact converse happens, and the ship tends to "draw" away before it is desired for her to begin moving. In a few unfortunate cases the downward motion, which commenced fairly enough, instead of being gradually accelerated, gradually ceases, and leaves the vessel partly launched. This happened at Millwall in the case of the large armoured frigate *Northumberland*, and still more recently the Brazilian ironclad *Independencia* (afterwards Her Majesty's ship *Neptune*) stopped on the ways. The *Northumberland* was uninjured; but the other ship was very seriously damaged in the bottom, and her repairs entailed a large expenditure. In both cases the cost of completing the launch was very great. There are also cases on record where the cradle has been imperfectly secured, and has slipped out of position before the vessel was afloat, letting her fall over on her side; and still others where the want of efficient ribbands on the launching-ways has permitted the bilge-ways to "spread" transversely as the vessel moved down the ways. This catalogue of accidents could be extended, but there is no need to do so; enough has been said to enforce the necessity for all possible care and precaution.

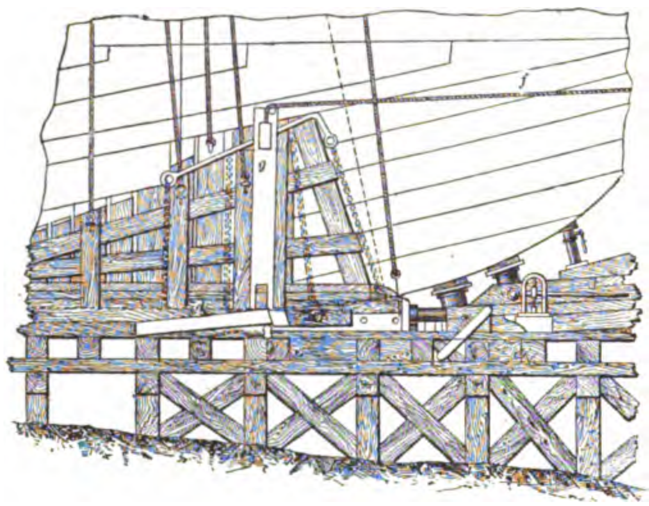


Fig. 3.—Enlarged View of Bow of the "Kaiser," showing important details of Launch.

When a vessel of large size stops on the ways it is frequently necessary to prepare "camels," or other means of imparting buoyancy to the after part, in order that as the tide rises the stern may be lifted off the launching-ways, and the fore ends of the bilge-ways alone left in contact. The friction of the bearing surfaces being thus reduced, it is usually a comparatively easy matter to complete the launch; but in the construction of the camels, as well as in their manipulation, great care is needed, in order that the amount by which the stern is raised may not be excessive, nor the stability of the ship imperilled. Sometimes it is necessary to construct new sliding-ways and a new cradle in order to complete the launch even with the aid of camels: this reconstruction of the launching apparatus being, of course, a very costly undertaking. It has been stated on good authority that over ten thousand pounds were spent on the four large camels used to lift the stern of the *Northumberland;* and this was but one item in a total expenditure of very large amount. Mr. Samuda estimates that on the completion of only three unsuccessful launches of large war-ships no less than three hundred thousand pounds must have been spent—a sum which would go far towards building a first-rate ironclad.

The preceding remarks apply exclusively to the method of launching commonly adopted in this country when ships are built "end-on" to the water. Another method sometimes adopted for ships of moderate size is to have one launching-way only, placed under the keel; and to prevent the ship from falling over as she slides down the way by means of fixed buttresses built under the bilges. Timber chocks secured to the bilges move along closely adjacent to, but not in contact with, the tops of the buttresses: so that if the ship heels over slightly from the vertical her tilting is checked by bringing the bilge-chock on one side down upon the buttress. It is not always convenient to build ships end-on to the water; and instead they are placed broadside-on, as was done with the *Great Eastern.* The process of launching is then very like that described above, only there may be more than two launching-ways; they are placed farther apart to sustain the vessel more efficiently, and they, as well as the cradles, are situated at right angles to the keel instead of being parallel to it. Fig. 4 shows a cross section of the *Great Eastern,* with the launching-ways and cradle. There were two launching-ways, each 120 feet wide; "180 feet of the bow projected beyond the forward way, 110 feet were unsupported between the two ways, and 150 feet of the stern projected beyond the afterway." The vessel in her launching condition weighed no less than 12,000 tons, and had to be moved over 200 feet down to

the position where she would be floated at high water. The ways were laid at a slope of 1 in 12; they consisted of "a network of timber resting on a thin bed of concrete, and on the top of the timber network were placed rails (iron), which formed the actual sliding surface." There were eighty rails on each way, laid lengthwise, or at right angles to the keel of the ship; they were of the pattern ordinarily used on the Great Western Railway. The cradles were constructed strongly of timber, as shown in

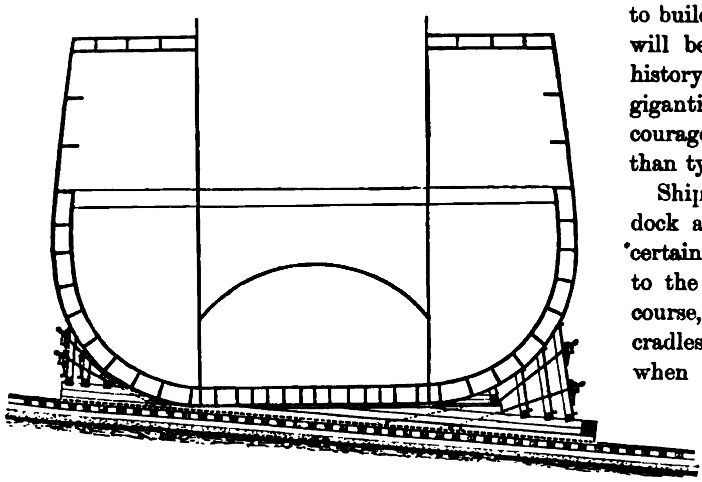


Fig. 4.—Cross Section of the "Great Eastern," with Launching-ways and Cradle.

the section; they were over 80 feet in length, and on the under-side of each were secured about sixty iron rails, fixed parallel to the length of the ship, and crossing at right angles the rails on the sliding-ways. The weight was carried during the launch on 9,000 intersections of this system of rails, each intersection carrying $1\frac{1}{3}$ tons. We need not state the reasons which induced Mr. Brunel to depart from time-honoured practice, and use iron rails instead of greased sliding surfaces of wood; it is sufficient to say that he made a series of careful experiments, which seemed to promise complete success in the launch. Nor need we detail the story of repeated failures in successive attempts made to launch the vessel, or relate how over one hundred thousand pounds were spent before she was set afloat. Even the severest critics of Mr. Brunel's novel system of launching join in the admission that no finer example can be found of his skill and perseverance as an engineer than was furnished by the operations which followed the failure of the first attempt. From November 3rd, 1857, until the end of January, 1858, Mr. Brunel was engaged without intermission on a task of the greatest difficulty, under very adverse circumstances. There is no probability that an undertaking of similar character will have to be attempted again; and when one reviews the whole history impartially, as can now be done, it is clear that the wiser course would have been either to launch the vessel at an earlier period of the progress, when her weight would have been less, or to have first constructed a dock capable of receiving her during construction and after completion. Should it ever be desired to build another *Great Eastern*, such a dock will be found at Milford Haven; but the history of the enterprise of which that gigantic vessel was the subject does not encourage the building of ships of that leviathan type.

Ships of large size are usually placed in dry dock after they are launched, in order that certain parts of the launching-gear attached to the bottom may be removed. It will, of course, be understood that the bilge-ways and cradles come to the surface of the water when the ship is afloat, and can be towed away, but the securities for the heads of the "poppets" and other small pieces are usually fastened to the bottom. Not unfrequently, however, the cradles on opposite sides of a ship are secured by chains passing under the keel, and then the launch can be cleared without docking the ship. Sometimes ships are practically completed before they are launched; and there have been cases where vessels have been set afloat with spars on end and steam up, ready to proceed on a passage. Such cases are rare; more commonly a steamer is launched before her machinery is put on board, and a sailing-ship before her masts are in place. Except in vessels of very moderate size this course of procedure is undoubtedly safer; and it usually facilitates progress in the completion of the work. With small vessels it is obviously possible to do many things safely that would involve serious risk if carried out on a larger scale.

Not a few of the largest vessels yet built have been constructed in dry docks, to which the water has been admitted in order to float them when the work was completed, or sufficiently advanced to make it desirable to move the vessels to another berth. The risk and difficulty of such a method do not compare with those incidental to launching; on the other hand, there are few cases outside the Royal Dockyards, where costly graving docks can

be assigned to ship-building. Such docks are primarily constructed for purposes of survey and repairs of ships, and in most ports they do not exist in numbers sufficient to enable some of them to be withdrawn from their legitimate occupation. Among the exceptional cases may be named the famous *Great Britain*, which was built in a dock at Bristol, and the ironclads *Achilles*, *Bellerophon*, *Hercules*, *Sultan*, *Temeraire*, and *Devastation*, built in docks at Chatham and Portsmouth. The floating of vessels constructed in this manner seems a very simple operation, but it usually requires to be conducted with care. It is desirable beforehand to ascertain approximately the draught of water and trim at which a vessel will float, in order to ensure her safe passage over the blocks and dock-sill. The conditions of stability may also require investigation, otherwise there may be a repetition of the accident that happened to the *Perseverance* troop-ship at Woolwich, which vessel fell over on her side when she floated in dock. There must be no doubt as to the sufficiency of the space at the dock entrance for the easy passage of the vessel, otherwise there may be a difficulty like that which occurred when the *Great Britain* was undocked at Bristol. The story is thus related in the *Life* of Mr. Brunel:—"On December 10th, 1843, everything was ready for her passing into the Avon through the lower lock. A steam-tug commenced towing her at high water, but before she had moved half her length in the lock it became evident that there was not an inch to spare; she was touching the lock walls on either side—in fact, she had stuck between the copings. Upon this orders were given to haul her back as quickly as possible. This was hardly effected before the tide began to fall; a few minutes later and the ship would have been jammed in the entrance." It seems not a little remarkable that in such a case actual measurements were not taken before any attempt was made to pass the vessel through the lock.

The converse case to launching is to be seen in the "hauling-up" slips used for repairing ships. There are various plans for such slips, but the principle is the same in all. A permanent slip-way is built, and carried out for a certain distance beyond high-water mark. Upon this slip-way a cradle travels, moving downwards under the action of gravity, and being drawn up by means of hydraulic power or steam power. When a ship is to be taken upon the slip the cradle is run down to its lowest position at the outer end of the slip, the vessel is grounded upon the cradle and suitably supported by blocks under the bilge, tackles led to the mast-heads, &c. Having been thus steadied in position on the cradle, it and the ship carried by it are drawn up the slip above high-water mark, where the work of survey or repair can be proceeded with uninterruptedly. Sometimes if there is an exceptional demand for accommodation, or if the work to be done is of a very extensive character, ships are launched broadside-on from the cradle to the ground adjacent thereto, and placed on blocks during the progress of the work. To an ordinary observer the ease with which comparatively heavy merchant ships are thus handled and transferred from place to place on dry ground by experienced workers is not a little remarkable. With very heavy ships the corresponding operations would, of course, be very difficult, if not impossible.

HEALTH AND DISEASE IN INDUSTRIAL OCCUPATIONS.—XII.

SOME REMARKS ON PRESENT SOCIAL AND SANITARY CONDITIONS.

By Andrea Rabagliati, M.A., M.D., Honorary Surgeon to the Bradford Infirmary.

I PROPOSE in this last chapter to consider some aspects of the social and sanitary condition of our industrial classes not hitherto referred to. It is no doubt satisfactory to observe how much they have improved in general well-being. Not only have wages much increased within the last generation—that might not mean much, since money has fallen in value—but present wages can purchase a better supply of the necessaries of life, buy better clothes and in greater variety, and provide better houses, with fuller and more elaborated accommodation, than was the case thirty years ago. And not the least pleasing part of the improvement of affairs is that all these advantages have been gained with shortened hours of work. The statistics referred to by Dr. Hogg in one of the earlier chapters of this series show also that factory operatives have, to say the least of it, not degenerated in physique. As to longevity, I shall have something further to say immediately, but it may be asserted

now that not only has it increased during the last thirty years, but it has vastly increased. But although we can truthfully congratulate ourselves that so many and such important improvements have been effected, there are still too many evils in the condition of the industrial Britain of to-day, and it is to some of these I now wish to direct attention.

The first evil to which reference must be made is the great increase which is taking place in the consumption of alcoholic drinks. Few persons are aware of the extent of this increase. Since the year 1872 trade has been bad in this country, wages have been reduced, and the profits of capitalists have diminished. Nevertheless, during that period the amount of money spent during each year on alcoholic drinks in the United Kingdom has remained at nearly the same figure. In 1873, when although the depression existed, it could not be said to have affected the people generally, the drink bill showed an increase of about £8,500,000 sterling over that of the preceding year, and reached £140,000,000. Since then it has been nearly stationary, with the exception of the year 1876, which showed an increase of nearly £5,000,000, which, however, was lost in the succeeding year. In 1878 the expenditure stood at a little over £142,000,000, practically the same as that of 1877, but with a remarkable difference which should be noted. In 1878 the money spent on wine and spirits (drunk mostly by the rich and middle classes) was less by about £2,000,000 sterling than in 1877, while the sum spent on beer (chiefly consumed by the industrial class) showed an increase of about £2,000,000. How much the sums spent upon alcoholic drinks have increased of late years will be seen if it is remembered that in 1863 the total amount did not exceed £92,000,000 sterling. Between 1863 and 1878 the increase of population was about 15 per cent.; but the increase of money spent on alcoholic liquors was about 54 per cent. It may be said, of course, that the increase in the consumption of beer in 1878, coinciding, as it did, with a decrease to a similar amount in the consumption of wine and spirits, depended rather on the middle classes drinking less wine and more beer, owing to the depression in trade, than an increased beer-drinking among the working people. This is probably true to some extent, but at any rate there is no proof, from the figures, that the mass of the people are drinking less than formerly, although the grand totals of one year may fluctuate somewhat as compared with those of another. Very various estimates have been made by different inquirers as to the number of deaths caused annually by intemperance. The teetotallers have kept repeating that 60,000 drunkards died annually in the United Kingdom; while the Registrar-General's returns give some 1,500 deaths as due annually to drinking. Manifestly, however, this latter figure gives no idea whatever of the actual numbers dying from drinking, since, besides that it is important not to wound unnecessarily the feelings of surviving friends, medical certificates rarely go back to the original causes of the ailment which has ended in death. Thus we find deaths certified as from disease of the liver, lungs, brain, or kidneys, as the case may be, without the addition that such diseases have been induced (as they often are) by indulgence in alcoholic drink. Keeping in mind facts of this sort, and computing from the results experienced in his own practice for seventeen years, as also from the estimate founded on returns from the experience of twelve medical men, and testing his conclusions in a large number of ways, some of them very ingenious, Dr. Norman Kerr has computed that "at least 120,000 of our population annually lose their lives through alcoholic excess." Now, as there occur in the United Kingdom about 700,000 deaths annually, rather more than one in six of these deaths, if this calculation is correct, might fairly be returned as due to drinking. This much should be said for Dr. Kerr's conclusion: that it originated in an attempt on his part to controvert the statement of the teetotallers that 60,000 drunkards annually die in the United Kingdom. Other authorities agree with him more or less. The well-known coroner Mr. Wakley has calculated that something like 12,500 deaths occur annually from this cause in London alone, and this estimate would give about 120,000 for the whole kingdom if calculated out in the same ratio. Other authorities have testified to the moderation of Dr. Kerr's estimate, while by some it is considered to be below the real proportion. Thus Dr. Richardson estimates that our national vitality would be increased by one-third if we were a temperate nation. If this is so, it means that a saving might be effected by temperance of about 230,000 deaths annually in the United Kingdom.

Dr. Hogg, in order that he might be able to make certain valuable suggestions on the subject, has already referred to the large amount of infant mortality which goes on in this country, and particularly in the manufacturing districts. I am not going to repeat what he has said so well, but I

wish to make one or two remarks on the subject from a different point of view. Of the 500,348 deaths from all causes registered in England and Wales in 1877, 120,611, or not far from one-fourth, occurred among children under one year old. In 1876 there were 130,000 deaths of children under one year old, and a competent medical authority has estimated that a great number of these infant deaths were due to the pernicious delusion of "nursing mothers that they require to be kept up by alcoholic liquors." Still more pernicious is the custom obtaining among some mothers and caretakers of the lower classes of feeding infants with gin and other alcoholic drinks. It is difficult to estimate what proportion of the intoxicating drink annually consumed in this country is really necessary, in any fair use of the word, to even the grown-up persons who use it. My own opinion (and I think this is even much within the mark) is that not more than one-tenth part so consumed is either necessary or advisable, in any fair use of these words. If this view is correct, what a tremendous amount of waste is undergone by the country in the loss from remunerative and productive business of the £126,000,000 sterling which represent the unnecessary nine-tenths of our national drink bill. But whatever may be said of this opinion as to the usefulness or otherwise of the consumption of alcoholic drink in general, no medical man can do other than condemn as absolutely and utterly useless and injurious the whole of the intoxicating drink which is given as food to tender infants; and if the ignorant mothers who resort to this hurtful practice could only be induced to put an end to it, the country would certainly be spared some at least of that appalling infant mortality which now afflicts it.

Because the kind of opinion to which I am now giving expression is so self-evident, much of it is not now expressed for the first time; but until recently it has always been open to the supporters of the present state of things to say that working people could not find either in their own homes or anywhere else the comforts which are afforded them at a cheap rate in the public-houses. Whether the expenditure is cheap or not is indeed a matter of opinion. Certainly a gross expenditure of £140,000,000 sterling is no small sum to pay. But each individual payment does not seem large even if the aggregate sum is enormous, and so long as the fact remained that no other accommodation of equal comfort was to be had at the price, those who opposed the expenditure as useless or injurious had nothing to say in answer. Recently, however, this argument has been upset by the foundation of coffee taverns in all the large towns of the country, in which, at a small cost, substantial meals of good quality are supplied to those working people who find it inconvenient to go home for their food. It is a matter of great thankfulness to those who have long opposed the drinking customs of the country that there is now no longer the excuse for their continuance that could be urged in the absence of any other place of refreshment than the public-houses, and it is very satisfactory to be told by the directors of the new establishments that the industrial classes are making large use of them.

Another point which cannot be looked on as satisfactory in the condition of the industrial England of to-day is the state of pauperism. It is not generally known that rather more than three persons out of every 100 (3·19 per cent.) of the population of England and Wales are in receipt of poor law relief. No doubt the number is not so great, either absolutely or relatively, as it was some years ago. In the year 1870 the per centage of pauperism (4·82) was the largest known; and in 1871 the numbers of paupers attained their maximum, reaching 1,085,661 out of a population of 22,782,122, or 4·76 per cent. of the population. In 1877, 1878, and 1879 the per centage of pauperism to population, which had been steadily decreasing since 1870, again began to increase, being 2·98 per cent. in the first of these years, 3 in the second, and 3·19 in the last. How far these figures may be connected with those just given, relative to the drink expenditure in the country, and how far with depression of trade, it is beyond our purpose to inquire; but whichever cause be the more potent the result is very unsatisfactory if one has regard to the morals of the people or to the laws which govern the distribution of wealth. There is one fact, however, in connection with pauperism whose significance should be weighed by any one who wishes to understand the subject. That is the present and past condition of insanity in the country. We often hear in a vague way that insanity is on the increase among us, but what are the facts? In 1859 the total number of pauper lunatics in England and Wales was 31,782; in 1869 the number had increased to 47,002; and in 1879 to 62,107. These steadily increasing numbers are exclusive of those insane who could pay for themselves or whose friends could pay for them. The numbers of these latter have increased from 4,980 in 1859 to 7,778

in 1879. It is often said that the increase in the number of lunatics is due to the better registration of lunacy which prevails now as compared with twenty years ago. This may be the case to a certain extent, but it is not credible that this cause can account for the whole increase, which in the case of pauper lunatics amounts practically to one hundred per cent. It is probable that registration has not improved so much in the case of private as of pauper lunatics, since the friends of the former, it is well known, will make almost any sacrifices in order to prevent their relatives from being declared insane; and this feeling was as strong twenty years ago as it is now. Nevertheless, the increase in the number of private lunatics during the last twenty years is 56 per cent.; and it seems fair, therefore, to conclude that the increase in pauper lunacy, apart from the amount due to better registration, at least equals this figure. On what does this increase depend? A large number of causes will be found in the Government returns on the subject, for it is impossible here to refer to all of them. But I find that domestic trouble, adverse circumstances (including money trouble), and other mental worry account for 17·7 per cent. of the cases; intemperance in drink accounts for 14·6 per cent.; previous attacks, either in the individual or in his ancestors, account for 35·3 per cent.; while those of which the causes are unknown amount to 22·8 per cent. It ought to be said that these causes are not necessarily exclusive of each other: that is to say, two or more of them may act in a given case. On the other hand, it is the rule in asylums to name as few causes as possible; and in many instances only one predisposing and one exciting cause is enumerated. This custom manifestly renders it impossible to make out from the returns into what per centage of cases any given cause enters, all that we are able to infer being that it was the chief cause in a given number of cases. The fact that mental worry is a chief cause in so large a number as 17·7 per cent. of the cases, and drink in 14·6 (drinking itself being often induced by worry), is an important corroboration of the frequently repeated statement of medical men, and sometimes of moralists, that the pressure of life to-day is greater than the reason of many of us can endure. Travelling with risk and anxiety at sixty miles an hour rather than safely at thirty or forty; undertaking in the haste to be rich three times as many things as could be done well; in the same spirit entering on speculations far beyond our means; fears lest the dishonesty of the age may cheat us of the due reward of our labours, even when these are faithfully performed; inability, through pressure of business and anxiety, to take rest when the nervous system admonishes us by numbness or sleeplessness that it is overdone; and lastly, the effort to drown for the time in stimulants the symptoms whose significance cannot be permanently ignored: these are some of the causes which have raised the proportion of lunatics from 1·8 per 1,000 of the population to 2·7 in twenty years. Lastly, the large proportion of lunacy caused by hereditary transmission indicates the necessity of training public opinion to discourage, if not prevent, marriage where the blood is so tainted. This subject, however, is too wide for discussion here.

The present mortality from what are called zymotic diseases, or, in the language to which we have now become accustomed, diseases due to organic matter in a state of change, happily shows a decrease as compared with former years. In 1877 the number of deaths from these affections was at the rate of 2·6 per 1,000 persons living, as against 3·3 and 3 per 1,000 in the two preceding years. This is a satisfactory diminution, especially when it is remembered that the rate in 1877 was 1 per 1,000 less than the average of the seven preceding years. Nevertheless, there is still much room for improvement, for it should not be forgotten that the 64,454 deaths from these diseases in 1877 were nearly all due to preventible causes. If, instead of polluting our rivers and wells, and poisoning our population with the sewage which comes from the land, we were to return it to the land in the form of manure, we should not only vastly increase the fertility of the soil, and so add to our national wealth, but we should certainly reduce to a minimum diseases at present caused by the wrong disposal of this matter. If, moreover, architects and builders, instead of scamping their work by laying pipes through which sewage cannot run, except to percolate under the house floors; by ventilating sewers into nurseries and bed-rooms and over drinking-water cisterns, instead of into the open air, and even in some instances by simply conducting the sewage into the ground instead of into the sewer, would do their work with honesty and conscientiousness, much improvement might be effected even on the present system, imperfect though it is. Failing this, much experience (on which these remarks are founded, and which could be given in detail if necessary) leads me to the conclusion that the present state of things will never be effectually remedied until public opinion justifies a charge of manslaughter against any contractor to whose

negligence or dishonesty can be traced a death from typhoid fever, diphtheria, or other disease due to sewage poison.

In conclusion I wish to make a few remarks on the great waste of life which is still going on in this country. The average death-rate in England and Wales in 1877 was 20 per 1,000 persons. During the last forty years the average mortality has been at the rate of from 22 to 23 per 1,000. This gives an average duration of life of about 44½ years. In the cotton industry the average duration of life is stated to be from 47 to 50 years. This average appears higher than the general one, but is really a good deal under it, because no children under nine years of age are reckoned as belonging to the cotton trade; while the general average includes all the children born, *one-half of whom die before they are five years of age.* Supposing the low mortality of 20 per 1,000 were maintained for a generation, the average duration of life in the country would be 50 years. The limit of human life is often stated at 70 years, but indeed, when we see the large number of hale and active persons who live and do useful work for a much longer time, there seems no reason why life should in general terminate even at 70 years. Nevertheless, if the general average reached even this figure, there would be added to the longevity of the people of England and Wales alone (with a population of 24,500,000 in 1877) no fewer than 490,000,000 of years of human life in each generation! It is almost impossible to realise the meaning of these figures, or to imagine what amount of useful work could be obtained by this addition to the national life. But when it is further recollected that at least a half of these deaths occur when life is at its best, and when the fulness of experience is under the guidance of the ripest judgment, some faint idea of the appalling waste and loss may perhaps be formed. It does indeed seem lamentable that so many industrious persons should leave life just when their training is completed, and before they have time to benefit their country and themselves by the carrying out of the labour for which their short life has been only a preparation. To some of the causes of this waste of life I have already referred. Most of them are preventible, as I have indicated; and although there is no doubt reason to be thankful for the improvement which has taken place in our day, it still cannot be denied that an industrial system which culminates in such fearful evils is far from satisfactory.

IRON AND STEEL.—XXVI.

SWORDS AND SWORD CUTLERY.

By Charles Hibbs.

In the course of that incessant struggle for existence which has occupied man from the earliest stages of his history till now, it has always been a matter of prime necessity for him to supply himself with weapons of one sort or other. Weapons of war or of the chase, weapons of offence or defence—these were indispensable in the first degree to him who alone, among animals, came into the world naked and unarmed. Consequently it happens that the progress of mankind in the dark pre-historic ages can now best be traced by the remains of their weapons. Nay, as we trace farthest back, it is the *only* method left to us. The earliest relics of man's handiwork are the flint arrow and spear heads so dear to modern archæology. And even far onward in the march towards civilisation, the gradual improvement in weapons marks more clearly than does anything else the successive steps of progress made. The archæologist and the historian have been compelled to pay special attention to this class of facts; and, repugnant as it may be to the instincts of a lover of peace, the deepest interest attaches to the discoveries of the means used by our forefathers to kill and maim each other. As the arts of life advanced, so did apparently the devices for its destruction. Each era of development is marked by the invention of more and more deadly implements of war. We cannot, if we would, avoid regarding with curious interest and with a kind of pride, the proofs of the gradual growth and awakening of the human intellect as shown in the growing ingenuity which, from age to age, has been bestowed upon the fabrication of weapons.

In common with all arts, the origin of this particular one must be traced back to Nature herself. The earliest savage weapon was doubtless a knotted stick or club, but an observation of the natural

arms which certain wild animals were furnished with would soon give the idea of something less rude and more effective. The sharp bills of birds would at once suggest the employment of a pointed weapon; the horn of the rhinoceros, would afford an example of a more deadly thrust; the tusks of the wild boar would be seen to have the peculiar property of cutting as well as of merely penetrating and lacerating the flesh; the porcupine had the singular power of projecting his quills; the serpent and the scorpion injected deadly poison into the slight wounds they were able to inflict. Here we have the rudimentary idea of all savage weapons—the spear, the hatchet, the sling and bow, the poisoned dart. The first rude contrivance for cutting or thrusting weapons would be the natural teeth and horns of animals fastened to wooden staves; then—long after, probably—the incipient effort would be made to fashion something out of the raw material of the earth; and, in shaping his first spear-head of stone, man became for the first time a producing animal. Wonderful epoch in his history, if he had but known it!

The flint spear-head or dagger was the precursor and almost the model for all similar weapons down to our own day. It was leaf-shaped—again an evidence of the teachings of nature. What the patient savage lacked in skill he made up in assiduity; the slow lessons of experience guided his hand, and stood him in the stead of mechanical aids. His weapon was chipped with such admirable regularity that it was not much inferior in form and finish to the metallic one fashioned after it far later on, and yet the only tool he could have used was another flint. So effective, indeed, were these weapons that when the next great stage of progress came—when the metallic arts had birth, and man emerged into the Bronze Age—flint would seem to have waged with bronze, for a time at least, equal warfare. In some ancient tombs bronze weapons and flint weapons have been found together, showing that both were in use at the same time.

With regard to early bronze weapons, it has been pretty generally asserted that some method of hardening was known which made the metal equal to iron and steel, and that here is an instance of a lost art. Be that as it may, the earliest specimens we have were evidently constructed with a view to meet the defect of softness and ductility. They are cast; of a thick, heavy, clumsy form; and the cutting edge is merely a narrow rim of thinner metal. Spear-heads had sometimes a thick rib or ridge running down the centre to stiffen them. Later specimens might show that the natural softness of the metal had been in some way overcome; but no great success could have been attained in that direction, or otherwise the bronze weapons would not have given place to those of soft iron, which succeeded them in order of date. While on this subject we may remark that modern invention *has* succeeded in producing hard bronze, and that chisels, shears, and other cutting instruments, besides various kinds of weapons, have been made of it. This is a material called phosphor-bronze, and its hardness is due probably to the admixture of phosphorus or some other substance. But there is no evidence that the ancients possessed the same or any similar secret; their weapons were perhaps hardened by hammering, as they might be to a considerable extent, and even then they were found to be inferior to the iron weapons which the primitive armourers were capable of producing.

It would take far too long to describe the many great and curious additions to man's power for mischief which came into existence after this era. We are dealing now, under the general head of Swords and Sword cutlery, with a class of arms which even at the present day embraces many varieties, as pikes, lances, bayonets, daggers, and all kinds of cutting and thrusting weapons, for which, in the English language at least, there happens to be no generic term. The French have a term—*armes blanches*—by which is roughly understood all small arms other than fire-arms; but for this we have no equivalent. The nearest approach we have is the military term, side-arms; but this could hardly be applied to the lances of a cavalry regiment, to the boarding-pikes of a man-of-war, or to the javelins of a high sheriff's retinue.

The class of arms we have in view will, however, be easily understood, though not easily designated, and it will be seen at once what an infinite variety they comprise, from the earliest times till now. We can but glance at a few of the most peculiar and interesting among ancient weapons as we proceed.

Our old masters, the Romans, retained all through their long history the short, heavy sword familiar to all classic readers, the original of which was of bronze, and perhaps most suitable of all shapes to that metal. They do not seem to have availed themselves of the harder qualities of iron and steel to lighten their weapons, probably because, in the close hand-to-hand fighting of those days, they

found the old pattern most effective in cutting through the defensive armour of wood and leather worn by their foes. One of the most curious of Roman arms was the *pilum*, of which the following description occurs in the "Encyclopædia Britannica:"—"It is a pike with a stout iron head, carried on an iron rod about 20 inches in length, which terminates in a socket for the insertion of the wooden shaft. As represented on the monuments, the iron part of the weapon is about one-third of its entire length, and its juncture with the wooden part of the shaft is fortified by a knob or swelling which is peculiar to this weapon. When used as a javelin at short distances it had a most embarrassing effect. Piercing the shield, the slender iron neck of the weapon bent with the weight of the shaft, which then dragged along the ground, so that the shield was rendered useless for defence. When used at close quarters, it not only answered all the purposes of the modern bayonet, but when firmly wielded in both hands it was equally effective to ward off sword strokes, which fell harmless upon the long and strong iron neck of the weapon. Polybius states that the legionary receiving the sword strokes with cool steadiness upon his *pilum* soon turned the swords of the enemy into mere hacked and blunted strigils and skinscrapers." The Frankish warriors of the Middle Ages adopted the idea of the pilum in a weapon which they called the *angon*. When the angon was fixed in the enemy's shield, the Frank soldier darted forward and trod upon the trailing pike, then killed his foe with a stroke of his sword. The Franks were also skilled in the use of the battle-axe, which they used occasionally as a *missile*, and with it would pierce a shield and kill the man behind it. During this period of history the common weapon of the foot soldier was the pike or spear, and the sword became, what it now is, peculiarly a horseman's weapon. Some swords of Scandinavian make have descended to us from the early Iron Age, rich with embellishments, and in shape setting the type that became characteristic of the feudal period. No longer the short, sturdy weapon of the Roman legionary, but a long, straight, terrible implement, that would crash through helm and hauberk when wielded by a doughty arm. From the twelfth to the seventeenth century—a period which saw the rise and decadence of body-armour—we find the changes in the form of swords and other like weapons keeping pace with the changes in the fashion of armour of defence. As in our own day we have witnessed the progress of the duel between irresistible projectiles and invulnerable armour-plate, so were the Middle Ages spectators of a contest between weapon and mail. The craftsmen who fabricated the suits of armour which became more and more elaborate with every generation sought to produce a covering which should be impenetrable to any arm then known; and, as soon as they had effected this, other armourers produced weapons that would pierce any mail that could be made. These were the days of huge two-handed swords, which, slung from the shoulder, trailed their points upon the ground; of ponderous mace and battle-axe, of long and heavy lance, of tough yew bows and cloth-yard shafts. At last the weight of arms and armour became so great that a knight in full panoply was scarcely able to bear it, and it was quite clear that a limit had been reached beyond which it was not possible to go. But, in the course of that duel, what racking of brains what patience in experiment, what nursing of skill, what new discoveries of the properties of iron and steel, for which the world is all the richer now! The Crusaders taught us new lessons: they brought the heavy-armed European knight and the light-armed Saracen into comparison, and showed that quickness and dexterity with the slenderest and most delicate weapons were sometimes more than a match for weight. The swords of the East have always been remarkable for high quality, temper, and finish, and their extreme lightness enables them to be used with those swift motions which produce such wonderful effects. Everybody has read, in the magic pages of Scott, of the trial of strength and skill between King Richard and Saladin, when the former cleft in two an iron mace with his heavy two-handed sword, and the latter divided a silken cushion, and afterwards a gossamer veil, with his sharp curved scimitar, "of a dull blue colour, marked with ten millions of meandering lines, which showed how anxiously the metal had been welded by the armourer." Such swords are to be met with now, their beautiful Damascus figuring making them of great value to the collector. They will bear an excessively fine edge, and are so light that a practised hand can wield them with the rapidity of lightning. In the Saladin trick, as it is termed by those who practise it for exhibition, it is not merely the sharpness of the weapon, but the lightning suddenness of the impact, that produces the effect.

The Orientals seem likewise to have been the first to study the principles which govern the "form" of swords and other cutting weapons. From them

we have borrowed nearly all our notions. The exact degree of curvature, the distribution of weight, the diminishing rigidity from hilt to point, the precise sectional figure—all were matters of great moment and mathematical nicety. It would be too sickening to detail here the reasonings of the authorities on the subject, or the experiments which have been made with a view to ascertain how wounds the deepest and deadliest could be most scientifically inflicted. Suffice it to say that scientists *have* most carefully examined these matters, and that the form of the weapons in use in all the armies of the world has been more or less determined upon such researches. The British cavalry sword is a sort of compromise of several principles, and perhaps the best that could well be arrived at. It is adapted for cutting and thrusting, and so has little curvature. It is heavy enough to crash through an infantry helmet, and yet not too heavy to be used with rapid motions. It will bear either a fine or a strong edge, is tough without being soft, and hard without being brittle. To the other weapons of this class in use in the British army similar remarks will apply. The lance, the bayonet, the sword-bayonet, the sapper's sword and axe, are all admitted to be the most effective for their purposes of any extant.

With regard to the processes of manufacture, there is little that need be minutely described. Great care is of course exercised in the production of sword-steel, which is delivered in bars of suitable shape called "moulds." Each mould will form two swords, being cut through at the middle. The blade is beaten out on the anvil at two or three heats, and a dexterous workman will, in a very short time, produce a sword perfectly accurate as to shape, length, weight, and gauge, with a well-formed hollow on either side running down to within a foot of the point, and the double edge of the forward part tapered down to a nicety, his only tools being his hammer, and one or two steel blocks held in twisted osier twigs. The hardening and tempering of the blades is a matter requiring much skill and experience, as will be apparent presently, when we come to speak of the tests to which they are subjected. The sword-hilter's work must also be sound and good. A cavalry hilt consists of three pieces—viz., the "grip" or handle of wood covered with leather; the pommel and back in one piece; and the guard, or protection for the hand. The tang of the blade passes through all these, and is firmly riveted on the top, while two ears attached to the back embrace the grip, and a rivet passes through crosswise and unites all into one piece. Regulation scabbards are made of sheet iron bent over and soldered at the joint, the ornaments and projecting parts being likewise soldered on. Both swords and scabbards are brightened by filing, grinding, or polishing on emery "bobs." Considerable ornamentation is bestowed on the hilts of presentation or ceremony swords, which afford a great opportunity for fine filing, chasing, or damascening; these are also frequently richly gilded. The blades of such weapons are sometimes blued for part of their length, and a device in gold traced thereupon, or they may be enriched by a method erroneously called "embossing." This consists in painting upon the blade, with an impervious varnish, some ornamental device, and afterwards applying an acid which "roughs" or "deads" all the parts left uncovered. When the varnish is removed the device appears in bright lines upon a dead ground.

The blades of bayonets are forged in like manner to sword blades, and afterwards welded on to a lump of iron fashioned into the rude semblance of a neck and socket. The sockets are drilled out of the solid to fit on to the end of the gun-barrel, and the little locking ring is sprung on and screwed. Lance-heads are likewise forged and welded to lanyets or "straps" of iron, which are let into and screwed to ashen poles. The tests for all such arms are most severe. Among other things, swords are struck with great force upon wooden blocks, first with the edge, and afterwards, being held by the blade with a cloth wrapped round the hand, on the back near the hilt, several times; and the least shakiness after such treatment would condemn them. They are also bent one by one into the form of a semicircle, first one way and then the other, by means of a board having a row of pegs so arranged, with a loop to receive the point; and, after such bending, they are expected to spring back to a straight position. They also undergo a microscopical examination for flaws, &c. Bayonets and other arms are tested in a similar manner, and in all cases great nicety is exacted in the matters of weight and gauge.

We have mentioned in a previous chapter that sword cutlery was an established trade in Birmingham at the time of the struggle between King Charles and his Parliament. One manufacturer, Mr. Richard Porter, supplied 15,000 swords to the parliamentary general, but no one in the town would supply the king's forces for love or money. The sword trade of Birmingham was in high repute

at the time of the Restoration, but afterwards, from some cause or other, it seems to have fallen off; at least, we find no mention of it till the eventful times of the '45, when we hear of swords and cutlasses being made in large quantities for the Pretender. The town seemed fated to be in opposition to the established powers; and as, a hundred years before, Prince Rupert had taken vengeance on it for its disloyalty, so now the emissaries of King George kept a sharp look out after its doings with regard to this "contraband of war." Several consignments were seized in transit and confiscated, and—curious link connecting those times with the present—a large chest of basket-hilted swords, made in Birmingham, and destined for the use of Prince Charles, was seized on the very spot from which these pages are issued—the Belle Sauvage Inn on Ludgate Hill, London.

In 1780, or thereabouts, the first government contract seems to have been placed here. Previously, the War Office had been deriving its supplies from abroad, and had conceived, perhaps not unnaturally, a prejudice against the revolutionary town. One Mr. Gill, a leading manufacturer, made great efforts to obtain a share of the orders, and invited a trial of his weapons against those which were being procured. It is said that his swords were so well tempered that they "would cut through a gun-barrel, or twist like a ribbon and go straight again." The result of the contest came off most triumphantly for him, and thenceforward not only he, but the other sword manufacturers of the town, were fairly treated in the matter of contracts. There were immediately after this time four large firms in operation, employing many hundreds of hands; and we may imagine that the long French war which soon after ensued gave an enormous impetus to the trade. From that time to the present Birmingham has been identified with this manufacture as much as with that of firearms, though of late the trade has languished to a great extent, owing principally to the extension of government manufactories.

The visitor to a modern sword-factory will, however, see about him evidences of a great and flourishing industry. He will see lying about, in various stages of completeness, heaps and heaps of blades—short, stumpy, and cheap-looking—which afterwards he will see in the warehouse, with common stained wooden handles attached, being packed for transmission to the sugar plantations in the West Indies and elsewhere. These are matchets, used for cutting down sugar-canes, and are turned out in Birmingham by hundreds of thousands of dozens. At present these form the staple of local sword cutlery.

While writing on the subject of sword cutlery, reference can hardly be avoided to the experiences acquired, during the Soudan campaigns, of the very imperfect quality of many of the bayonets supplied to the brave men who were doing gallant duty for their country. A large proportion of the weapons were found to "twist" after short service and to be practically useless. After the fighting the arms in stock were subjected to a test, and many were discovered to be faulty. Comment on the cruelty of exposing British soldiers to the dangers of battle without providing them with absolutely reliable weapons is needless.

WOOL AND WORSTED.—XXVI.

THE WEST RIDING CLOTH TRADE.

By William Gibson.

A GLANCE at a map of England will readily explain the pre-eminence which the West Riding of Yorkshire has attained as a manufacturing centre. Communication by land and water is naturally easy, and the artificial waterway that connects the Mersey with the Humber runs through it. The towns and villages, therefore, may be set down as contiguous to the great ports of Liverpool and Hull; and, since the introduction of railways, the area is so covered with lines as to present the appearance of a cob-web on the map. Besides, the great midland coal and iron fields lying at the doors, manufacturers can be provided easily and cheaply with raw material for making and working machinery. These are exceptional advantages, but they only partially account for the wonderful activity

and enterprise of the locality. The character of the people, and their perception of the proper avenue for the exercise of their operations, account for all the rest.

Compared with the West of England, the natural and artificial advantages of the situation are incalculable; yet Yorkshire has never really been a competitor with the other woollen districts in Hants, Wilts, Somerset and Gloucestershire. It left the west to produce the finer and dearer qualities of broadcloth, and aimed at supplying the millions at home and abroad with medium and lower stamps of material at the cheapest possible price. The result has been that, where one piece is demanded from the former district, ten are bought in the latter, and the rapidity of return compensates for the narrow profit with which manufacturer and merchant are content. In the western counties the trade is chiefly in the hands of men who engage in all the processes, whereas in Yorkshire there is a greater distribution of labour. The preliminary processes, from sorting to spinning, are in Yorkshire carried on in enormous factories; weaving is for the most part relegated to village artizans; the fulling, again, is done in large establishments; the cloth in that condition is taken to market and sold; and it is then finished by firms whose sole business it is to crop and dress the materials.

Leeds, being the most important town in the riding, deserves first mention. In 1373 there was but one fulling-mill in the place, but the Pipe Roll —or High Sheriff's account—of 1272 shows that there were clothiers located in the neighbourhood of the old Castle. In the reign of Edward III., Thomas Burgess was leaseholder of the fulling-mill, which was valued at £1 13s. 4d. a year. The motive power was derived from water drawn from the river Aire at its outflow from the Castle moat. Leland, in 1536, found a considerable trade carried on in the town, which, according to him, was then "as large as Bradford, but not so quik." The last phrase has given huge offence to every historian of Leeds since, but what was true in the time of Bluff King Hal holds good to-day. There can be little doubt but Bradford is the more "active" (quik) town. When James I. came to the throne the town had between 3,000 and 4,000 inhabitants, and a contemporaneous chronicler said "it standeth most by clothing." The old fulling-mill was valued at £3 11s. 8d. per annum. The first Cloth Hall was built in 1711, in consequence of a panic caused by "merry Wakefield" having raised a similar structure. Previous to this, cloth was bought and sold on open stalls which stood on the Bridge, but in consequence of increasing trade the market was shifted to Briggate in 1684. The hall was built in Kirkgate, and stands were provided for 100 clothiers. About half a century afterwards, business still prospering, a second building was called for, and in 1758 the old Coloured Cloth Hall was constructed in Tenter Croft. It was a plain edifice, consisting of an oblong and two wings enclosing three sides of a square. The interior was divided into six rows or streets, in each of which were two rows of stalls. Each salesman was allowed a frontage for his tiny *boutique* of 22 inches, and room was found for 1770 standing-places. The concern was, to use a modern phrase, "a limited liability," each shareholder having the freehold of his own few feet of space. About 1775, the White Cloth Hall was found altogether inadequate; and a larger one, containing 1,210 stalls, was built in the Calls. It was a square building of two storeys in height, and its dimensions were 297 feet by 210. So that in ninety years the business had increased about thirtyfold. In 1711 only 100 stalls were needed, and in 1801 places had to be found for about 3,300 vendors.

Up to this date the entire trade was in the hands of yeomen manufacturers, the first factory—then an entire novelty—having been built in 1793 by Messrs Wormald, Fountayne, and Gott. This factory was burnt down in 1799, and another was put up in its place by Messrs Wormald, Gott, and Wormald, and it was the forerunner of all the large establishments now to be found in the district. To show the increase of production that took place in about thirty-five years, it may be stated that in 1769 there were produced 1,771,667 yards of broad and narrow cloth; whereas in 1778 no less than 4,244,322 yards of broad and 4,208,303 yards of narrow cloth were made, and in 1805 no less than 9,987,252 yards of the former and 5,460,179 yards of the latter were sold in the halls. This shows an advance of about 500 per cent. in no less than forty years; and even thus early in the age of mechanical inventions the district showed a decided preference for cheap medium materials. The fancy articles then were swansdown, toilonets, kerseymeres, and duffles. Attached to the Coloured Cloth Hall was an octagonal building used as an exchange for merchants. Besides the two cloth halls there was a supplementary building for the accommodation of such producers as had not served their time as cloth-workers; and at the beginning

of the nineteenth century the principal manufacturers were Messrs. Marshall, Benyon, Wormald, Gott, and Fountayne. At this time some six or seven steam engines were at work, and wages ranged from 7s. to 30s. per week, but one man now did as much work as had been accomplished 150 years before by 35 persons.

While the population of Leeds has risen during the present century from about 53,000 to something like 260,000, the horse-power employed has advanced in the same time from about 300 to over 8,000, and over 50,000 persons are at present directly engaged in the woollen trade of the town and surrounding district. This growth, enormous as it is, may be said to have mainly taken place since 1820 or so. In 1826 the Leeds and Liverpool Canal was opened, and not many years after railways began to bring hitherto isolated villages fairly within reach, while improved machinery has for the last six decades advanced by leaps and bounds. The bill which enabled the North Eastern Railway Company to bring a station into the town swept away the White Cloth Hall, and a new and larger structure was put up in Infirmary Gardens in 1868. Since 1873 the Coloured Hall has had to be opened daily, but the ancient market days were Tuesday and Saturday. The business done in these public places, however, by no means exhausts the commerce in cloth carried on in the town, for it has been computed that pieces valued at from £6,000,000 to £7,000,000 are annually disposed of in the private warehouses of the merchants. Nor is it for wool alone that Leeds is notable. The flax and linen factories, iron works, machine shops, and chemical manufactories that exist rank almost as high in the industrial world. In the district the joint-stock proprietary system is much in vogue. Small manufacturers own a portion of a large factory, bring their wool to be sorted, washed, combed and spun, and subsequently to be fulled. The varieties of cloth made are plain broadcloth, all wool, and cotton warp, Spanish stripes, fancy coatings, trouserings and vestings, ladies' cloth, felt carpets, and many others; and the principal manufacturers are, besides the descendants of those already named, Messrs. Hargreaves, Nussey, Barran, Birchall, Eyre, &c. Very little English wool is at present used in the district, except for carpets, flannels, blankets, and in the shoddy and mungo mills. Formerly, as in other clothing localities, the shorter flocks from long and medium woolled sheep, the "shorts" or down that came out in the process of combing, and the fleece of such breeds as the South Down were utilised; but now little even of continental produce is bought. The supply comes chiefly from Australia, New Zealand, Cape of Good Hope, and along the valley of La Plata in South America, whence a practically inexhaustible amount of raw material is attainable.

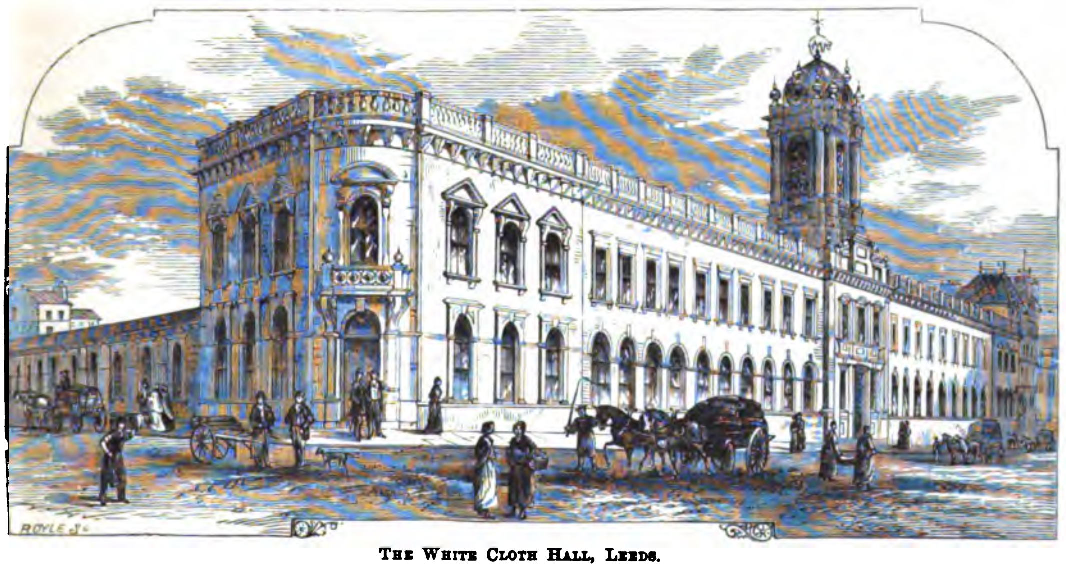
THE BRIGGATE, LEEDS, LOOKING NORTH.

Huddersfield, the town next in importance, lies at the south western extremity of the woollen district, and it drains the area from Wakefield on the east to the base of the Lancashire hills on the west. One indication of the rapid strides caused by its manufacturing industry is that between 1861 and 1871 the population was more than doubled—in the former year it stood at 34,877, and in the latter it was over 74,000. The first Piece Hall was built as late as 1768, and the next in 1780. Of all the great manufacturing towns of Yorkshire, it was the latest to make solid advancement, on account of the inveterate hatred displayed by its operatives to the introduction of machinery. It may be broadly stated that from 1811 to 1820 there were few intervals of repose from riot and

rattening; so that capitalists were, to a large extent, obliged to hold aloof from investing money in such a hot-bed of prejudice. This town was the head-quarters of the Luddites, whose conduct here as elsewhere was lawless to a degree. Attacks were made upon several mills; but mill-storming having become too dangerous, the only alternative left was to shoot those who were known to be most anxious to set up the new-fangled mechanical appliances. The lot was resorted to as the fairest means of distributing the positions of honour, as the rioters considered an appointment to shoot an employer; and the first victim whose life was taken was Mr. Horsfall, of Marsden, whose murderers escaped for the time. Another marked man was Enoch Taylor, of Marsden, a gentleman whose mechanical genius had been of considerable advantage to local manufacturers; but, as he slept always in Armitage Mill, which was strongly fortified, and rarely ventured out of doors in the day-time, the intentions of his enemies were successfully defeated. Government introduced a bill dealing with the nefarious organisation, which passed into law in February, 1812. Despite the secrecy endeavoured to be maintained, the authors of the outrage upon Mr. Horsfall were discovered; and, one of the four having turned king's evidence, the other three were executed on the 8th January, 1813. These trade disputes continued up to the year 1840, and Huddersfield remained true to the Luddite opinions. Large bodies of men threatened manufacturers in 1817, in 1820, and in 1842; and in the former years serious views were entertained of carrying the town by a *coup de main*, which was only frustrated by the concentration of a large body of military.

Despite all this opposition to machinery, however, Huddersfield has grown and progressed. To-day it gives promise of much more extended prosperity, and probably by far the largest amount of cloth used for trousering, both at home and in the colonies, is produced by the manufacturers in the town and immediate vicinity. It may be taken broadly that the enterprise, the perfection of machinery, and the quality of the goods sent into the market by Huddersfield manufacturers, stand in the very first order of merit.

Many of the villages to the west and south of Wakefield are still engaged in producing cloth, but in the town itself very little trade in this department is now carried on. But there are three considerable towns to the northward where cloth is the staple product. These are Dewsbury, Batley, and Mirfield, which have a joint population of not less than 70,000. We have already, in the chapter on Shoddy and Mungo, called attention to the chief speciality for which the district has of recent years become notable; but in all three places and the villages adjoining there are very considerable quantities of heavy cloths made, besides carpets and blankets, travelling and horse rugs. Heckmondwike and Birstal are almost towns, and in both there are large factories. Here the old yeoman patronymics still abound, such as Mark Olroyd and Sons, Messrs Howgate, Firth, Newsome,



THE WHITE CLOTH HALL, LEEDS.

Brierley, Colbech, Fieldhouse, Blakeley, and Wormald. The first-named firm employs considerably over 1,500 hands, and is one of the most complete establishments in the neighbourhood.

Halifax is the only other town which demands a reference here; and, although since the Crossleys began to confine themselves to carpet weaving they overshadow smaller manufacturers, it has always maintained its ancient and honourable reputation as a woollen mart, and was, till within recent years, the chief emporium of cloth merchants. That the tendency was towards large transactions so early as the sixteenth century is proved by the fact that Queen Elizabeth issued an edict against the sale of wool in such large quantities as to prevent the crofters and working people generally being able to get their raw material. Here, too, the first cloth hall in Yorkshire was erected by Viscount Irwin, in 1708; and such quantities of cloth were sold at the Saturday morning's market as to yield a profit, at a tax of a penny a piece, amounting to 40s. a week. Daniel Defoe, who visited the town in 1727, speaks of 100,000 pieces of shalloons being sold in that year, and one trader alone turned over £60,000 worth of kersies per annum. Shalloons, tammies, duroys, everlastings, calimancoes, and moreens were at the time the staple products; and Watson, the historian of the town, about a century ago, enumerated no less than 90 factories in the parish, without counting gig mills and smaller firms, engaged in raising and cropping cloth. At that time the town numbered some 8,000 inhabitants, and within 100 years there was a population of 65,124.

Crossley and Ackroyd have, since last century at all events, been the chief manufacturers. Dean Clough Mills, the property of the former, was originally a three-storied building on the banks of the Hebble, and was built by Messrs. Waterhouse. The old mills were pulled down in 1857, and replaced by the handsome pile which covers some twenty-five acres of ground, and in which over 5,000 work-people are employed. John Crossley, the founder of the firm, was born in 1772, and at the age of sixteen was apprenticed to his uncle Webster, of Claypits, to learn carpet-weaving. Subsequently he wrought as a journeyman for Mr. Currie at Luddenden Foot. In 1800 he and Job Lees went into partnership on their own account at Lower Grange Yard, but, the latter dying shortly after, the firm became Abbott, Crossley, and Ellerton. At the end of the first year Mr. Crossley took out £70 as his share of profits. The partnership was dissolved after a short existence, and Crossley confined himself for a time mainly to the spinning and dyeing of carpet-yarn. He had been joined by his brother and a Mr. Travis in 1802, and old Dean Clough Mill was leased by them for twenty years at £250 per annum. At the end of the term the share of stock, &c., taken by each of the partners was £1,400. In 1830 Crossley bought Messrs. Abbott's carpet business, which then consisted of from twenty to twenty-five looms, and to this he turned his whole attention. What ingenuity and enterprise he and his three sons displayed in carrying on the business is now a well-known story, and the success they met with is no less notable. But the Crossleys were not only successful manufacturers, but useful citizens and public servants who have left their mark. They have cheerfully assisted every worthy object and the amount of benefactions for public and private charities dispensed by the firm during the last fifty years would produce an almost fabulous total. The founder of the firm died in 1837, just as it began to assume gigantic proportions; but it was he who laid the firm basis of its subsequent career. His sons have shown themselves worthy descendants of such a father, and the benefits they have bestowed upon the town, as well as the amount of good they have done their own work-people, are incalculable. Originally Mr. John Crossley, sen., wove shalloons and plainbacks as well as carpets, although it was in the latter branch that he was best qualified to take the lead. Mainly, therefore, this firm comes into the category of worsted manufacturers, but the story of the West Riding would be incomplete without some reference to it.

James Ackroyd and Son are the other great Halifax mill-owners. The predecessor of the present proprietors was a cloth-weaver. James Ackroyd, grandfather of the existing head of the concern, was born in Brookhouse, Ovenden, in 1753. From a yeoman manufacturer of the type already referred to in the chapters immediately preceding the present, he launched into business on a larger scale. His brother Jonathan and he became partners between 1770 and 1780, and ultimately the two sons of the head of the house, James and Jonathan, were admitted into the concern. During the original co-partnery the firm was well known as excellent makers of lasting, calimancoes, wildbores, and plain and figured Amiens. In 1805 the junior partners built the old spinning-mill at Brookhouse to run Arkwright's spinning-jenny, the machinery being set in motion by a water-wheel fed by the

contents of an aqueduct about half a mile in length, by which water was drawn from the neighbouring river. At the time this was considered a remarkable piece of work, and was designed, we believe, by one of the partners. In a few years weaving was added to spinning, for in 1811 we find moreens being one of the novelties in their books. It will probably always be a moot point whether the honour of first making this class of goods is due to the Ackroyds, or to John Holland, of Stead; but certainly it was one or the other. In this year James Ackroyd withdrew from the Brookhouse firm, and started on his own account at Old Lane. He was the mechanical genius of the family, and perhaps, in a manufacturing sense, the ablest of the sons of James Ackroyd, sen. He was amongst the first, if not actually the first, to introduce the power-loom in 1822; but, at all events, it is to him that we owe the introduction of the Jacquard machine in 1827. As early as 1825 he was supplying the well-known firm of Mackintosh and Co. with the material for rendering water-proof, for which they have ever since been famous; and between 1830–2 he was making mixed goods with cotton warps, as well as all-wool damasks and other figured fabrics. James Ackroyd the younger died in 1836.

Meanwhile Jonathan remained at Brookhouse in partnership with the third son of the original founder of the firm, but the latter retired in 1823. In addition to the factory at Brookhouse, Jonathan bought the steam mill at Bowling Dyke, and in 1839 his two sons were taken into the concern. Jonathan died in 1847, and in 1853 the partnership between his two sons was dissolved, leaving James the sole proprietor; and in 1871 this gentleman transformed the business into a joint-stock concern in order to benefit the workmen who had been instrumental in making the firm successful. This portion of the original firm has in recent years assumed very large proportions. In addition to the works at Bowling Dyke, where the preparatory processes are now mainly carried on, the firm runs the combing and weaving sheds at Haley Hall; dye-works adjoining Bowling Dyke, purchased from Messrs. Edleston; dye-houses at North Bridge; and especially the splendid establishment known as Copley Mills, covering ten acres of ground, and surrounded by over 150 dwelling-houses for the work-people. To James Ackroyd is due the introduction of bombazine and crape, paramatta, coburgs, and camblets; "French figure," figure Russell with mohair weft, dobbies, and numerous other novelties. Three of the gentlemen who were admitted into the joint-stock company a few years ago as having contributed to the flourishing condition of the firm were Messrs. Greenwood, Dawson, and Wood. They mastered the technical difficulties of various branches of the Norwich trade, and in turn became the tutors of those who were to bring much of it to Yorkshire. James Ackroyd showed genuine appreciation of these labours in 1871, and his action in this respect deserves every commendation.

The following list will show the dates when various novelties were introduced by the firm:—1798, calimancoes, plain and ribbed, lastings, and prunelles; 1803—serge de Berri, shalloons, Russells, and wildbores; 1811—moreens, says, and duroys; 1813—three-quarter bombazettes, or plainbacks; 1819—bombazines and crapes; 1824—damasks; 1826-7—French merinos and full twills; 1829—camblets, taborines, fancy Russells, and dobbies; 1834—French figures, single warp and merino weft; 1836—alpaca figures; and 1836-40—figured Orleans and cotton-warped goods. It will thus be seen that the Ackroyds have chiefly been engaged in worsted goods, but this firm is deserving of a distinguished place in the annals of the great industrialists of the West Riding of Yorkshire.

SHIP BUILDING.—XXX.

THE LIFEBOAT.

THE Royal National Lifeboat Institution is an organisation of which this country may well be proud. Founded in 1824, under the title of the National Shipwreck Institution, and reorganised in 1850, it has continued the noble work of rescuing life from shipwreck, and has gradually encircled the British Islands with its stations. Its operations are manifold, as well as extensive; the sympathy and support it receives are world-wide. Each winter adds to the long list of the gallant deeds done by lifeboat crews; and furnishes fresh evidence of the success that has been achieved in

the construction of lifeboats. Absolute immunity from accident is of course unattainable on such a service : those who brave the storm and tempest to carry help to the perishing, necessarily peril their own lives in the attempt. On the other hand, the experience of more than half a century, and the constant endeavour of skilful men to improve the character of the lifeboat, have resulted in the production of a type which reduces the chance of accident to a minimum. The sailor, the naval architect and the practical ship- or boat-builder have united in aiding this progress; and it would be difficult to point to any better illustration of the advantages resulting from united effort. Compared with the huge iron-clad, or the magnificent mail steamer, the lifeboat may appear an insignificant specimen of naval architecture, yet in her design there are embodied an epitome of the principles of ship-construction, and every detail of the structure has to be closely scrutinised in order that the little vessel may well fulfil her noble mission. Let us endeavour to sketch briefly the features which distinguish the lifeboat from other boats, and enable her crew to face the heaviest weather with a reasonable prospect of safety. It will be convenient to introduce this description with a short narrative of what was attempted in life-boat construction prior to 1850; and for these particulars we are mainly indebted to the very excellent book on "The Lifeboat and its Work" written by the late Mr. Richard Lewis.

The first lifeboat of which there is any record was designed, in 1784, by Mr. Lukin, a coachbuilder in London, and, strange to say, a native of an inland town. He chiefly aimed at making an *unsinkable* boat, or, as he termed it, an "unimmergible" boat. This he accomplished by attaching a considerable amount of cork outside the boat above water, and by constructing inside the boat a series of water-tight spaces, or compartments. The volume to which water could find access, if a sea broke over the boat, was thus reduced considerably, and the buoyancy of the cork belt helped to keep the boat afloat if she were thus swamped. An iron keel was fitted to increase the stability. The plan of construction was sound so far as it went, although far inferior to that now adopted; and it is a matter for regret that only one boat on Lukin's plan was placed on the coast. In 1789 another attempt was made in this direction, a dreadful shipwreck having occurred at the mouth of the Tyne, and awakened public sympathy so far that premiums were offered by the inhabitants of South Shields for the best models of a lifeboat. The prize was awarded to a local boat-builder, Mr. Greathead, who is commonly reputed to be the inventor of the lifeboat, and certainly did much to extend the employment of lifeboats at home and abroad. Like Lukin, Greathead was content to aim at securing the buoyancy of the boat; only he relied chiefly on the use of cork worked inside the boat, and upon a water-tight platform or deck built about a foot above the keel. The ends of the boat were raised high above the middle in order to increase her power of meeting heavy seas, and she was propelled by ten oars. In 1791 Greathead's first boat performed its earliest duty, and between that year and 1798 it did much useful work. No other boat was built meanwhile, and, until the Duke of Northumberland displayed a liberal interest in the matter, it seemed probable that Greathead would fail as Lukin had done. A start having been made, further progress was for a time comparatively rapid, and "before the end of 1803 Greathead had built no fewer than thirty-one" boats. In 1802 Parliament voted £1,200 as a reward to the Tyne boat-builder, who could then boast that 200 lives had been saved by his boats; and other public bodies showed their appreciation of the value of his services to the mercantile marine. The first boat built by Greathead continued at work thirty years; it was finally wrecked at the mouth of the Tyne, but without loss of life to the crew. Even up to the present time, specimens of these early and comparatively imperfect lifeboats are to be seen at certain stations; and the writer has heard expressions of preference for these boats over the later models from the hardy fishermen of the north-east coast. It cannot be doubted, however, that such a preference is unwise and prejudiced, although it is natural that the long-continued service of a boat—like that at Redcar, for more than seventy years—should establish it in the affectionate esteem of the fishermen.

Until 1824 there was no Society which undertook the duty of establishing and maintaining lifeboats on our coasts. All that was done was the work of generous individuals, like the Duke of Northumberland, who was Greathead's patron, or of local associations, like that at South Shields, moved to action by some great disaster. In March, 1824, the "Royal National Institution for the Preservation of Life from Shipwreck" was founded; and from that time until 1850 it continued to do good work, but chiefly in the direction of increasing the number of lifeboats. For a quarter of a

century, improvements in the construction of life-boats seem to have proceeded very slowly; and a careful investigation, made in 1850, disclosed the following defects in the boats then at work:—

(1) That they did not right themselves in the event of being upset;

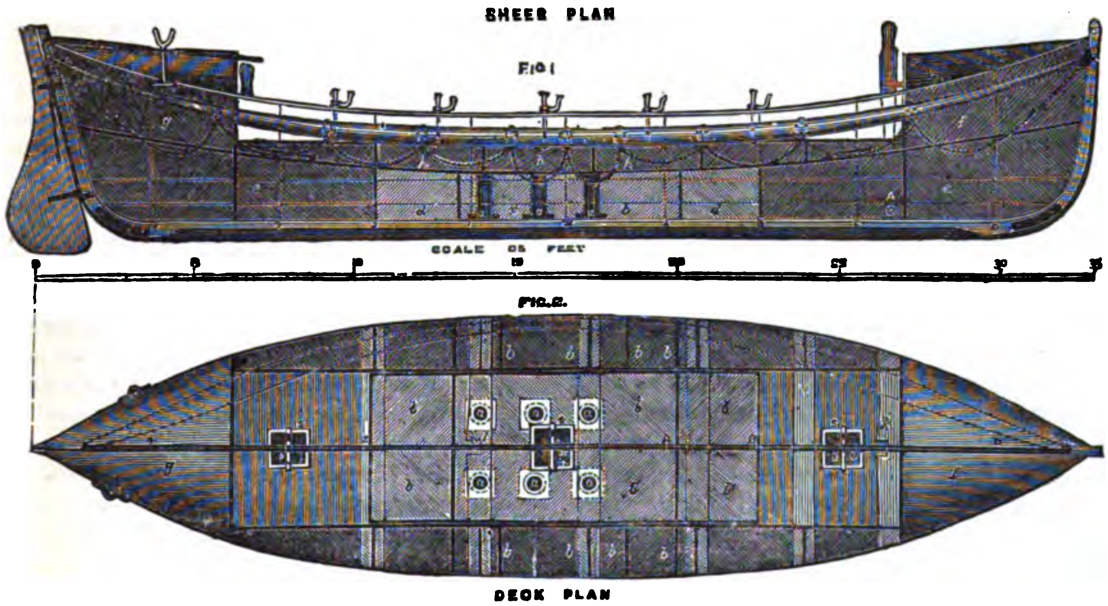
(2) That they were too heavy to be readily launched, or transported along the coast in case of need;

(3) That they did not free themselves of water fast enough; and

(4) That they were very expensive.

not a few places on the coast life-boats were falling into decay or remaining unemployed. And the lamentable accident just mentioned was indirectly a means of good; for, to quote Mr. Lewis once more, "the mind of the nation having been directed to the existing state of things, men could no longer view with apathy the increasing loss of life from shipwreck, the many and fatal accidents to inefficient life-boats, and the entire absence of any (boats) along extensive lines of coast in these islands."

The labours of the committee nominated by the



FIGS. 1, 2.—WORKING DRAWINGS OF THE LIFE-BOAT OF THE NATIONAL LIFE-BOAT INSTITUTION.
a, delivering-tubes for clearing water; *b*, cork ballast stowed beneath water-tight deck; *f*, air-case at bow; *g*, air-case at stern; *h*, air-cases at sides.

Such was the summary of faults contained in the notice which the Duke of Northumberland caused to be issued in October, 1850, inviting a general competition for the prize of 100 guineas to be given for the best design of an improved life-boat. This fresh effort was the result of an accident which happened to the South Shields boat nearly at the close of 1849. Out of a crew of twenty-four men no less than twenty were drowned, including many of the best pilots of the port. "It is but justice to add," says Mr. Lewis, "that the life-boats at Shields had been in constant use since Greathead first launched his boat there on the 30th January, 1790, and that this was the first case where loss of life had happened." Shields had set a good example to all British seaports for half a century, in thus maintaining its life-boat agency, while at

Duke of Northumberland to adjudicate upon the various plans submitted by the competitors for his prize were most onerous. Their Report can still be read with interest and profit; it clearly enunciates the principles of life-boat design, and describes the method of procedure by which a selection was made of the best among the two hundred and eighty models and plans submitted, not merely by Englishmen, but from various European countries and from the United States. Six months were occupied in the careful scrutiny and comparison of the models and drawings, and finally the prize was adjudged to Mr. James Beeching, of Great Yarmouth. But the committee were of opinion that a better boat even than Beeching's might be designed, and Mr. James Peake, one of their number, undertook the task.

The Lords of the Admiralty generously authorised the construction of a boat on this plan at Woolwich Dockyard, and early in 1852 the boat was tested, proving a complete success. Subsequent experience has led to modification and improvements in many matters of detail, but in its main features the life-boat of the present day resembles that recommended by the Northumberland committee. Mr. Lewis sums up the case very fairly when he says: "The committee (of the Institution) and its officers have incessantly laboured to introduce into the construction of the boats every improvement that modern science and actual trials in the heaviest storms could suggest: so that the life-boat of the Institution may now be truly designated an *omnium gatherum*, and cannot be looked upon as any one man's design or invention."

Fig. 3.—Section of Life-boat at After Bulk-head.

In order to give greater precision to our remarks on the qualities requiring to be combined in a successful life-boat, we have chosen the 33-feet boat of the Royal National Institution, and the diagrams given in this and the previous page will illustrate the subject. It has been explained that in the earlier life-boats *unsinkability* was the quality most sought after; and in the present boats this quality is amply secured. On reference to the diagrams it will be remarked that there is a water-tight deck about two feet above the keel, approximately coincident with the level of still water when the boat is afloat. Further, at the bow and stern the interior space of the boat is filled by large water-tight air-cases, each having a length of five or six feet. Moreover, other air-cases are stowed along the sides of the boat, and still further limit the volume of the space to which the water can find access if the boat is swamped. A 33-feet boat weighs when fully loaded about $4\frac{1}{2}$ tons; the space under the deck has a buoyancy equal to $5\frac{1}{2}$ tons, and the air-cases have an aggregate buoyancy of $5\frac{3}{4}$ tons. Additional security is obtained by stowing cases filled with cork in the space under the water-tight deck; so that if the bottom of the boat is damaged or broken through, the presence of the cork shall limit the quantity of water that can enter. It will be seen, however, that even if the whole of the buoyancy of the space below the deck were lost, the air-cases would have sufficient buoyancy to keep the boat from sinking. Cases have occurred where the life-boats have struck on rocks or shoals and had their bottoms stove in, yet have remained perfectly manageable, and have performed the duty on which they were proceeding when the accident happened. It will suffice to add that the use of lightly-constructed water-tight cases as a means of obtaining a reserve of buoyancy is a necessity, as the weight of cork required to obtain an equal reserve would be a serious addition to the weight of the boat, and make her transport over land much more difficult. A 33-feet boat weighs about $2\frac{3}{4}$ tons when light, or when being transported, and $4\frac{1}{2}$ tons when her crew and stores are on board. In order to obtain a reserve of buoyancy of $5\frac{3}{4}$ tons about 2 tons of cork would be needed, whereas a much less weight worked into air-cases will suffice, the only risk run being that of breaking through the cases by blows. This risk is small, as the cases are built of stout boards, and those at the ends of the boat have their surfaces covered with cork one inch thick.

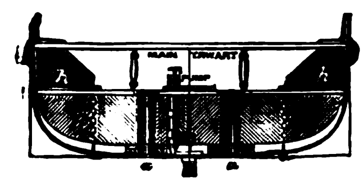


Fig. 4.—Midship Section of Life-Boat. (Letter references as in Figs. 1 and 2.)

It will be observed from the diagrams that the unoccupied space in the interior of the boat is comparatively small. It is, in fact, made a minimum, consistently with the accommodation of the crew, and the provision of a sufficient space for the persons who may be rescued from a wreck. Obviously, the smaller this unoccupied space is made the less is the risk of foundering when a boat is swamped by a sea breaking on board. On the other hand, an unsinkable boat, if permanently "waterlogged," must become practically unmanageable and lose her speed. Hence it is highly desirable to devise some plan by which the water shipped may be rapidly cleared. The plan adopted in the boats of the National Institution, as well as in many other life-boats, is simple and effective: it will be understood by reference to the diagrams. Several cylindrical tubes are fitted vertically, extending from the bottom of the boat up to the water-tight deck, which is a little above water. At the upper ends of these tubes valves are fitted in such a manner that they can only open downwards when subjected to pressure from above. When a sea is shipped, the weight of water above the deck opens the valves, and the water is very

rapidly cleared. In the case of the boat designed by Mr. Peake, it was found on trial that less than a minute sufficed to clear the interior of water. Another reason for desiring to clear the water speedily is found in the effect which its presence has upon the stability of a life-boat. Were it not for the existence of the side air-cases, and the attachment of a heavy iron keel, it might and probably would happen that swamping would produce instability. As a matter of fact, swamping only produces a reduction in the stability for a short time, thanks to the prompt action of the automatic clearing-tubes and valves.

The Committee of 1850 also attached much importance to the self-righting quality in life-boats. Capsizing is by no means an infrequent occurrence, and it has led to great loss of life. The South Shields boat was thrown over longitudinally: she was not self-righting, but remained bottom-up, and finally drifted ashore in that condition. The model life-boat built from Mr. Peake's designs was an excellent example of what might be done to secure the power of self-righting: when she was upset purposely, she righted in five seconds. All subsequent boats built for the National Institution have been designed on similar principles, and, whether capsized when under oars or under sails, have always righted. At first some persons were inclined to believe that other and even more important qualities would be sacrificed in securing self-righting power; but the experience of thirty years has removed all such doubts. Mr. Lewis states that from 1852 to 1874 35 self-righting boats, carrying 401 men, were upset, the loss of life being 25; whereas the upsetting of 8 other boats not possessed of self-righting power was accompanied by the loss of 87 lives out of 140 men on board. Most visitors to sea-port towns will have witnessed the experiment of a life-boat being intentionally capsized in order to exhibit her self-righting power, and they will have noted the fact that the crew wear cork life-belts, which enable them to keep afloat without effort until they regain the boat, if they are thrown out of her when she is capsized. It is an invariable rule that the crew shall wear such belts when they go afloat, and to this rule must be attributed the preservation of many valuable lives. The life-belts are admirably designed to enable the men to perform their arduous work of rowing in a heavy sea without inconvenience, and Admiral Ward deserves and receives the gratitude of all life-boat crews for the pains he bestowed on every detail of the belts.

The method by which the self-righting power is obtained is at once simple and ingenious. A comparatively heavy iron keel is secured to the wood keel of the boat; and by this means, as well as by the cork ballast stowed under the deck, the centre of gravity of the boat is brought low down. When she is upright this low position of the centre of gravity adds to her stability, and enables the stability to be maintained even when the boat is momentarily swamped. On the other hand, if the boat is unfortunately capsized—either by being thrown over transversely, or tilted up and overturned longitudinally—the centre of gravity is, of course, very high. At the same time, the weight of the boat is chiefly carried by the narrow but bulky air-cases at the bow and stern. Consequently, the boat is in unstable equilibrium when bottom up, and cannot find rest until she has once more righted.

Life-boats, being built for service in rough weather and under exceptionally trying circumstances, require to have hulls of great strength; and, on the other hand, they have to be built as lightly as possible, in order that they may be transported readily. The system of construction closely resembles that long used for the larger boats of the Royal Navy. The skin is formed of two thicknesses of half-inch mahogany plank, worked diagonally, with the planks of one thickness crossing those on the other thickness nearly at right angles. This skin, strong in itself, is further stiffened by suitable framing, by the water-tight deck, and by the thwarts on which the rowers sit. The air-cases also assist in keeping the boat to its form under some circumstances, although primarily fitted to preserve the buoyancy. It is scarcely necessary to add that, in the choice of materials, the character of the workmanship, and the arrangement of every detail, scrupulous care has to be exercised, if the best possible results are to be obtained. Foolish economy in such a matter might lead to a practical loss of the whole expenditure. Hence, in proportion to her size, although not in proportion to her service, a life-boat is an expensive construction. At present, the cost of a 37-feet life-boat fully equipped is about £500, and the average annual cost of keeping up a life-boat station is about £70. Into the details of the arrangements for housing the boats and transporting them from place to place, we cannot enter here. Suffice it to say that care has been taken by the responsible officers of the Institution to secure and maintain the highest efficiency in every branch of the service.

Interesting particulars upon these matters (which are somewhat beyond our province) will be found in Mr. Lewis's excellent book; and no one who has the opportunity should fail to visit a life-boat station, and observe the constant state of readiness in which the boat and all its equipments are kept, for upon this constant watchfulness and regular exercise depends in no small degree the confidence with which, when the hour of need comes, the life-boat is launched upon her mission of mercy.

The skill of British sailors and naval architects has produced a type of life-boat which well fulfils its purpose, and is not likely to be soon replaced. The liberality of the British public enables the Life-boat Institution to prosecute its noble and humane work on a grand scale; but without the services of the gallant men who form the crews, all these preparations would be of no avail. It is true, no doubt, that these men receive payment for their services; but who would venture to assert that the small payments made to the boatmen in any sense compensate them for the risks they have to run, or are the real attraction to those who volunteer for the service? These humble heroes "are mostly resident boatmen, fishermen, or Coast-guard men," all familiar with the sea, and all hardy, skilful oarsmen. This circumstance makes it important that the life-boats should be propelled by oars or sails, with the management of which all seafaring men are familiar. But, apart from this fact, there would be obvious dangers in attempting to fit steam-generating apparatus and propelling machinery in boats liable to being tossed about or capsized by heavy seas. It may perhaps be possible hereafter to introduce some other description of propelling machinery, by the use of which the number of men embarked in a boat may be reduced and the risk of losing valuable lives diminished. As yet, however, this problem is unsolved, and those most familiar with the service are not hopeful that a solution will be found.

The foregoing sketch of the characteristic features of the life-boat will have served its purpose well, if—besides informing the reader upon details connected with the structure of life-boats—it increases in any degree the interest which he may take in the work of the Life-boat Institution.

COTTON.—XXX.

DEVELOPMENT OF THE COTTON MANUFACTURE—IMPORTS AND EXPORTS—CURIOUS CALCULATIONS.

By David Bremner, Author of "The Industries of Scotland."

THE marvellous development of the cotton manufacture in the United Kingdom has been incidentally indicated in preceding chapters. Here we shall mention some facts which will more clearly exhibit the rapid growth and gigantic dimensions of the great industry. In the year 1741 the spinning and weaving appliances of the country did not work up more cotton wool than would form the cargo of a sailing ship of no remarkable dimensions, and during the fifty years prior to that time the average annual consumption was about the same. The value of all cotton goods exported ranged from £5,000 to £20,000 a year. The value of all the cotton goods manufactured was computed to be about £600,000 a year, and the number of persons employed certainly did not exceed 40,000.

Even in those early days the cotton manufacture experienced vicissitudes which it was feared would result in its annihilation. A Glasgow manufacturer, in giving evidence before a parliamentary committee in 1833, said:—"I have seen a great many overthrows in the cotton manufacture. In 1788 I thought it was never to recover; in 1793 it got another blow; in 1799 it got a severe blow; and in 1803 again, and in 1810: and at particular periods one would have thought that it was never to extend again." It weathered every storm, however, and, in the words of the gentleman just quoted, "every time that it received a blow the rebound was quite wonderful."

At various periods estimates have been drawn up for the purpose of showing the extent of the cotton trade. Mr. Kennedy, of Manchester, who had the best means of obtaining trustworthy information on the subject, supplied the following figures with reference to the year 1817:—Raw cotton imported, 110,000,000 lb.; yarn produced, 99,687,500lb., the remainder being waste; spindles employed, 6,645,833; persons engaged in spinning, 110,763. Mr. M'Culloch, in his "Dictionary of Commerce," gives an estimate for the year 1832, in which he sets down the total value of every

description of cotton goods annually manufactured in Great Britain at £34,000,000, apportioned as follows:—Raw material, 240,000,000 lb. at 7d. per lb., £7,000,000; wages of 800,000 weavers, spinners, bleachers, &c., at £22 10s. a year each, £18,000,000; wages of 100,000 engineers, machine-makers, smiths, masons, joiners, &c., at £30 a year each, £3,000,000; profits of the manufacturers, wages of superintendence, sums to purchase the materials of machinery, coal, &c., £6,000,000. Commenting in 1835 on this and other estimates, Mr. Baines says:—"On the whole, after an attentive consideration of all the official and unofficial evidence which has been presented, I am of opinion that the annual produce of the cotton manufacture of the United Kingdom must be between £30,000,000 and £34,000,000, and that the number of individuals directly employed in the manufacture, with those dependent on them for subsistence, must amount to 1,500,000." He set down the amount of capital, fixed and floating, employed in the trade at £34,000,000..

EDWARD BAINES.
(From a Portrait in possession of the Family.)

Mr. Joseph Spencer, of Manchester, prepared and read to the Manchester Statistical Society a most careful review of the cotton trade during the half century ending with the year 1875, from which we may select a few facts showing the progress of the industry during that period. The average consumption of cotton in the United Kingdom in the five years ending in 1825 was 154,200,000 lb.; in 1830, 212,300,000 lb.; in 1835, 295,200,000 lb.; in 1840, 405,700,000 lb.; in 1845, 521,300,000 lb.; in 1850, 569,800,000 lb.; in 1855, 750,100,000 lb.; in 1860, 947,300,000 lb.; in 1865, 628,600,000 lb.; in 1870, 973,800,000 lb.; in 1875, 1,228,600,000 lb. These figures show that the consumption of cotton in the United Kingdom had increased more than eight times in fifty years. This is a startling statement; but not less so is the fact that the consumption of cotton on the Continent of Europe had grown nine times larger in fifty years. In the five years ending 1825 it was on the average 92,600,000 lb.; and in the five years ending 1875, 856,600,000 lb. More astounding still are the figures which show that the consumption of the United States of America had multiplied thirteen and a-half times in forty-five years. In the five years ending 1830 it was 38,500,000 lb.; and in the five years ending 1875, 524,700,000 lb. These statements, taken together, show that the total consumption in the five years ending in 1830 was 370,600,000 lb.; and in the five years ending in 1875, 2,609,900,000 lb. That is to say, the consumption of cotton in Great Britain, the Continent of Europe, and the United States of America, taken together, multiplied seven times in forty-five years, or at the rate of nearly eight times in fifty years. Large as this increase seems, it was not so great at the end as at the beginning of the time. Making the year 1835 a starting-point, and dividing the interval between that year and the year 1875 into two periods of twenty years, it is found that the consumption of Great Britain increased 154 per cent. in the first twenty, and only 63 per cent. in the last twenty years. The Continent of Europe increased its consumption 216 per cent. in the first half, and 89 per cent. in the second; and the increase in America was 30·9 per cent. in the first twenty years, and only 8·6 per cent. in the last twenty. These three statements put together show a total increase in the consumption of the whole of 290 per cent. in the first period and 76 per cent. in the last. Measured by the standard of weight of cotton consumed, America increased the most, the Continent of Europe followed, and Great Britain stood last in the race.

These facts would naturally lead to the conclusion that the spinners of the Continent of Europe, and America, were gradually gaining upon the English spinners; but it is necessary, in forming an opinion, to remember that the weight of yarns made is an important factor. A country may at one time be spinning 20's twist and at another time 40's twist. In the first case she would require more, in the second less, cotton. In 1850 the number of spindles in the United Kingdom was 20,977,000; the quantity of cotton used, 625,200,000 lb.; and the weight per spindle, 29·8 lb.; while in 1875 the number of spindles was 37,500,000; the quantity of cotton used, 1,228,500,000 lb.; and the weight per spindle, 32·77 lb. A little calculation will show that if the weight per spindle had been the

same in 1875 as it was in 1850, the quantity of cotton consumed would have been 111,375,000 lb. less; and if the weight per spindle had been the same as in 1875, the quantity consumed would have been 75,375,300 lb. more than it was; so that if one country was spinning coarser yarns, and therefore weaving heavier goods than another, she would show an increase in the consumption of cotton in comparison with her competitor which would be fallacious. To further elucidate this point, Mr. Spencer showed what had been the increase in the number of spindles in the countries under review during the last half century. It appeared from the best authorities that in 1832 there were in the United Kingdom 9,000,000 spindles, and in 1875, 37,500,000. The total increase was, therefore, 28,500,000. On the Continent, in 1832, it was calculated that there were 2,800,000 spindles, and in 1875, 19,500,000—an increase of 16,700,000. The United States, in 1832, had 1,200,000 spindles, and in 1875, 9,500,000, so that the increase was 8,300,000. Therefore, although it was true that the increase in the consumption of cotton in the last fifty years on the Continent of Europe was equal to, and the increase of that of the United States of America far exceeded, the increase of Great Britain, still it was also true that our spinners had set to work 24·3 per cent. more spindles than the Americans, and 72 per cent. more than the Continental spinners. These conclusions seemed contradictory, but they were reconciled when it was discovered that the average counts of yarn and the goods produced in the United Kingdom were lighter and finer than the average of either the Continent of Europe or the United States of America. The average weight per spindle per annum in the United Kingdom was about 33 lb., whilst in Europe it was 50 lb., and in America 60 lb. per spindle. Combining together the number of spindles set to work, the counts of yarn spun, and the weight of cotton consumed, it must be seen that the spinners of Great Britain still held the first rank in their trade.

The returns of exports of cotton goods and yarns from the United Kingdom to foreign parts showed that in 1830 the number of yards exported was 1,844,200,000; the weight, 368,800,000 lb.; and the value, £67,196,000. In 1875 the exports had risen in yards to 17,607,800,000; in weight to 3,521,000,000 lb.; and in value to £300,962,000. The export of yarns in the five years ending 1830 was 263,661,000 lb., and the value £18,793,000; while during the year 1875 the weight exported was 1,057,095,000 lb., and the value £75,343,000. After reducing the goods account from yards to lb. weight, the statement was—for the five years ending in 1830, goods, 368,800,000 lb.; yarns, 263,661,000 lb.; total, 632,500,000 lbs. For the five years ending 1875 it was—goods, 3,521,000,000 lb.; yarns, 1,057,059,000 lb.; total, 4,578,000,000 lb. The result of the whole was that the weight of cotton goods exported had multiplied 9·54 times, the weight of yarns 4 times, the value of goods 4·47 times, the value of yarns 4 times, the total weight of goods and yarns 7·23 times, the value of goods and yarns 4·3 times in the fifty years. It had been estimated that there was engaged in this manufacture a capital, fixed and floating, of £100,000,000, without reckoning the capital employed in consequence of its existence by merchants, brokers, engineers, and others. And yet, surprising to relate, all the people directly engaged in the mills did not exceed 500,000, of whom 54 per cent. were women, 14 per cent. children under thirteen, and 8 per cent. youths of the male sex under eighteen years of age.

The above facts may be usefully supplemented by a brief sketch of the trade in 1879, which will carry our survey down to the latest possible period at which a review may be safely taken. The year was most remarkable, as it witnessed the culmination of that depression in all departments of business which has continued ever since. The weight of cotton yarns and goods produced was 1,111,000,000 lb., which, though more than in the preceding year, was a considerable reduction from the figures of a number of years prior to that. Of the produce of the year, 984,000,000 lb. weight was exported, and 126,000,000 lb. retained for home consumption. The raw cotton cost £32,042,000, and the sum paid for wages in manufacturing it was £23,155,000. The wage account alone showed a falling-off of from two to three millions as compared with any of the preceding ten years. The balance left to the manufacturer for interest, profits, and all expenses other than the payment for cotton and wages was only 5d. per lb., as compared with 6·75d. in 1871. Now, as 6·26d. per lb., which was the average of the five years preceding 1876, is required to cover the charges referred to in a manner that will be fairly satisfactory to the manufacturer, we can calculate the effect of the reduced remuneration which fell to his share in the four succeeding years, when the figures respectively were 5·58d., 5·40d.,

5·09d., and 5d. In 1876 the falling-off was £3,289,000; in 1877, £4,213,000; in 1878, £5,599,000; and in 1879, £6,024,000; the total for the four years being the gigantic sum of £19,125,000. Subsequent improvements were, unfortunately, of a particular rather than a general character.

During 1879 we exported 3,718,138,000 yards of cotton piece goods, of which 1,056,741,000 yards were dyed or printed. Of stockings, we exported 1,110,000 dozen pairs; of yarn, 235,770,000 lb.; and of thread for sewing, 11,627,000 lb. The value of the piece goods exported was £46,838,000; of the hosiery, lace, &c., £3,163,000; of the yarn, £12,102,000; and of the thread, £1,843,000; the total value of all kinds exported being £63,946,000.

A good deal has been heard of the present and prospective effects of competition in the cotton manufacture, and that matter has been discussed in another part of this publication. The following table, showing the supplies taken by our principal customers at various periods, contains some suggestive facts bearing on this subject, and we leave it to speak for itself:—

locks-out have occurred at frequent intervals. It is not for us to discuss here the merits of these disputes. We can but regret their occurrence, as experience has shown that in the long run they can prove but little profitable to either party. The men who came so grandly through the terrible trial of the cotton famine should endeavour to understand each other better, and, working hand in hand, preserve their great industry to the country. Their quarrels may not yet have done much to strengthen the hands of foreign rivals, but must, if continued, produce before long results which all will deplore.

From the figures we have given relating to the cotton manufacture ingenious persons might work out a variety of calculations tending to show in a most striking manner the enormous extent of this branch of industry. For example, it could be demonstrated that the bales of cotton we import in each year would, if placed end to end, form a continuous rampart along the entire coast-line of Great Britain; that the yarn produced in the same time, taking it at the average of fifty hanks to the pound weight, which is a moderate computation, would measure no less than 26,515,840,909 miles in length, sufficient to reach from the earth to the sun 280 times; that if we could use the earth as a bobbin on which to wind this marvellous thread, we should be able to encircle it 1,060,633 times; that if the thread could be laid out in a straight

EXPORTS OF PIECE GOODS AND YARN TO THE PRINCIPAL DISTRICTS OF THE WORLD AT VARIOUS PERIODS, 1820—79, IN MILLIONS OF YARDS AND LBS.

	1820.		1830.		1840.		1850.		1860.		1870.		1879.	
	Yards	%	Yards.	%	Yards.	%	Yards.	%	Yards.	%	Yards.	%	Yards.	%
PIECE GOODS.														
Europe (except Turkey)	127·7	50·90	137·4	30·94	200·4	25·35	222·1	16·35	200·5	7·49	294·6	9·06	272·7	10·02
Turkey, Egypt, & Africa	9·5	3·79	40·0	8·99	74·6	9·43	193·9	14·27	357·8	13·37	670·5	20·61	486·5	13·08
America (except U.S.).	56·0	22·32	140·8	31·66	278·6	35·24	360·4	26·53	527·1	19·70	594·5	18·28	545·6	14·68
United States . .	23·8	9·48	49·3	11·08	32·1	4·07	104·2	7·68	226·8	8·48	103·3	3·18	51·2	1·38
British East Indies . } China, Java, &c. . }	14·2	5·66	56·9	12·79	145·1	18·35	314·4	23·15	825·1	30·83	923·3	28·38	1327·6	35·71
					29·9	3·78	104·3	7·68	324·2	12·11	478·2	14·70	626·6	16·85
All other countries .	19·7	7·85	20·2	4·54	29·9	3·78	58·9	4·34	214·7	8·02	188·4	5·79	307·9	8·28
Total yards . .	250·9	100·00	444·6	100·00	790·6	100·00	1358·2	100·00	2676·2	100·00	3252·8	100·00	3618·1	100·00
Total value, mln. £ .	13·2	—	15·1	—	16·3	—	20·5	—	40·3	—	52·5	—	—	—
YARN.	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%
Europe (except Turkey)	23·0	95·66	56·0	86·69	91·9	77·55	90·7	69·03	116·0	58·79	93·7	49·93	110·4	46·84
Turkey . . .	0·5	2·17	1·5	2·32	3·3	2·78	4·7	3·58	19·6	9·94	14·2	7·56	20·5	8·70
British East Indies . } China, Java, &c. . }	—	—	4·9	7·58	16·1	13·59	21·0	15·98	30·7	15·56	31·0	16·51	31·3	13·28
					1·8	1·52	3·1	2·36	8·8	4·46	20·8	11·08	39·0	16·54
All other countries .	0·5	2·17	2·2	3·41	5·4	4·56	11·9	9·05	22·2	11·25	28·0	14·92	34·5	14·64
Total lb. . .	24·0	100·00	64·6	100·00	118·5	100·00	131·4	100·00	197·3	100·00	187·7	100·00	235·7	100 00
Total value, mln. £ .	2·8	—	4·1	—	7·1	—	6·4	—	9·9	—	14·8	—	—	—

For a considerable time past the relations between employers and employed in the cotton manufacture have not been of a cordial kind. There has been constant disagreement in one quarter or another on the subject of wages, and strikes and

line, and a shot from an eighty-ton gun travelling at its highest speed of 1,500 feet per second, were fired along its track, it would take 2,368 years to reach the extremity; that the cotton cloth of all kinds woven annually would make a continuous web one yard wide and 2,445,171 miles in length, sufficient to cover an area of over 884,600 acres, or 1,382 square miles; and that the power-looms used in the production of this mighty web would, if placed side by side, with the smallest allowance of working space, extend from Brighton to John o' Groat's.

THE TEXTILE INDUSTRIES OF THE UNITED KINGDOM.

An account of the rise, progress, and varied processes of the leading textile manufactures of the country has been given under the respective headings; but it will not be deemed superfluous in a work like this if we take a brief survey of all the textile branches of industry, and show their combined magnitude. The means for doing this are afforded by a return to Parliament made up towards the close of the year 1879. This official statement is entitled "A Return of the Number of Factories authorised to be Inspected under the Factory and Workshops Acts, with the Number of Persons Employed in each Industry, distinguishing Men, Women, Young Persons, Children, and Half-timers; and also giving the Number of Spindles, Looms, and other Machines used in each of the Trades and Industries Inspected up to the 31st day of October, 1879."

Cotton takes the leading place; and there were in the United Kingdom at the date named 2,674 factories devoted to that fibre. In these 482,903 persons were employed, of whom 185,472 were males and 297,431 females. The operatives were further classified as follows:—(1) Number of children working half-time—males, 28,663; females, 33,260; (2) Males under eighteen years of age working full time, 34,730; (3) Females above thirteen years of age working full time, 264,171; (4) Males above eighteen years of age, 122,079. The total number of spindles was 44,206,690, and of power-looms 514,911. Of the factories, 2,579 were situated in England and Wales; and of these, 1,119 were exclusively devoted to spinning, 733 to weaving, 582 to spinning and weaving combined, and the remaining 145 were not classified. A large proportion of the factories was concentrated in Lancashire, the returns showing that that county had 753 spinning, 646 weaving, 490 spinning and weaving, and 87 unenumerated factories. Yorkshire came next with its 193 spinning, 46 weaving, 37 combined, and 10 unenumerated. Cheshire took the third place, with 97 spinning, 9 weaving, 41 combined, and 9 unenumerated factories. Derbyshire stood fourth in rank, and the north and west midland districts took nearly all the remainder. The 37 spinning factories in Scotland were situated chiefly in the counties of Renfrew, Ayr, and Lanark; and the same remark applies to the 30 weaving, 14 combined, and 8 unenumerated establishments. The total number of cotton factories in Scotland was 89. In Ireland there were only 6 cotton factories, of which Leinster had 3, Ulster 2, and Munster 1. The total number of persons employed in the Scottish cotton factories was 29,775, and in those of Ireland 1,620.

The woollen factories of the United Kingdom numbered 1,732, and employed 143,344 persons, of whom 64,280 were males and 79,064 females. The number of children working half-time was—males, 5,194; females, 4,216. Of males under eighteen years of age working full time, there were 11,258; females above thirteen years of age working full time, 65,848; and males above eighteen years of age, 47,828. The number of spinning spindles was 3,337,607, of doubling spindles 318,154, and of power-looms 56,944. Of the factories, 1,412 were situated in England and Wales; and of these, 420 were devoted to spinning alone, 65 to weaving, 786 to spinning and weaving combined, and 141 were unenumerated. Yorkshire was the chief seat of this branch, that county having 156 of the spinning factories, 52 of the weaving, 571 of the combined, and 80 of the unenumerated. Wales and Monmouth had 210 of the spinning, 42 of the combined, and 12 of the unenumerated factories. The others were widely dispersed, nearly every county having one or more. Scotland had 246 woollen factories, one or more of which might be found in every county. The north-eastern, south-eastern, and southern groups of counties had, however, the larger share. The number of persons employed was 22,667. Ireland had 74 woollen factories,

employing 1,975 persons. They were situated chiefly in the provinces of Leinster and Munster.

Of shoddy factories, England had almost a monopoly, 134 of the 137 establishments of that kind being in the chief division of the kingdom. The remaining three were in Scotland; so that Ireland was not represented in this branch of industry. The shoddy factories were for the most part situated in Yorkshire and Lancashire. They contained about 90,000 spindles and 2,110 power-looms, and gave employment to 5,079 persons.

There were in the kingdom 693 worsted factories, containing 2,096,820 spinning spindles, 456,114 doubling spindles, and 87,393 power-looms, and giving employment to 130,925 persons. The operatives were classed as follows:—Children working half-time—males 10,112, females 11,428; males under eighteen years of age working full time, 9,944; females above thirteen years of age working full time, 69,784; males above eighteen years of age, 29,657; total of males, 49,713; total of females, 81,212. Of the factories, 636 were in England, Yorkshire containing greater part of them. Scotland had 55 worsted factories, and Ireland 2.

In the 400 flax factories, there were 1,264,766 spinning spindles, 64,982 doubling spindles, and 40,448 power-looms, and employment was afforded for 108,806 persons. The latter were thus classified:—Children working half-time—males 3,209, females 4,823; males under eighteen years working full time, 7,678; females above thirteen years working full time, 72,148; males above eighteen years, 20,948; total of males, 31,835; total of females, 76,971. Of the factories, 101 were in England and Wales, 155 in Scotland, and 144 in Ireland. But to show the superior producing power of Ireland in this its great industry, it is necessary to give some details. In the 101 factories in England and Wales there were only 219,247 spindles and 4,081 power-looms, giving employment to 14,988 persons; and in the 155 Scottish factories there were 283,758 spindles, 16,756 power-looms, and 37,476 operatives. The 144 Irish factories, on the other hand, contained 826,743 spindles, 19,611 power-looms, and employed 56,342 persons. The English factories were chiefly situated in Yorkshire; the Scottish in Forfarshire, Perthshire, and Fifeshire; and those of Ireland in the counties of Donegal, Londonderry, Antrim, Down, Armagh, Cavan, Fermanagh, Monaghan, and Tyrone.

The hemp factories numbered 58, of which 50 were in England and Wales, 5 in Ireland, and 3 in Scotland. They contained 25,304 spindles and 74 power-looms, and employed 4,780 persons.

Jute was manufactured in 117 establishments, which contained 212,676 spinning spindles, 7,492 doubling spindles, and 11,288 power-looms, and employed 36,354 persons. Of this branch Scotland had almost a monopoly, 99 of the factories being situated in that division of the kingdom. England and Wales had only 12 factories, and Ireland 6. The operatives in jute factories were classified thus:—Children working half-time—males 1,542, females 1,980; males under eighteen working full time, 2,972; females above thirteen working full time, 23,800; males above eighteen, 6,060; total of males, 10,574; total of females, 25,780.

There were in the United Kingdom 36 factories for dealing with hair, and in these 1,731 persons were employed. The silk factories numbered 706, and contained 842,538 spinning spindles, 176,401 doubling spindles, and 12,546 power-looms. In this branch 40,985 persons were employed, as follows:—Children working half-time—males 1,440, females 2,820; males under eighteen years of age working full time, 2,171; females above thirteen years of age working full time, 26,292; and males above eighteen years of age, 8,262. Five of the silk factories were in Scotland and one in Ireland, the remainder being chiefly located in the midland counties of England. Of lace factories, the number was 283, one of which was in Scotland and none in Ireland. The operatives numbered 10,209—6,283 males and 3,926 females. There were 186 hosiery factories, ten being in Scotland and one in Ireland. They employed 14,992 workpeople, of whom 6,683 were males and 8,309 females. The number of elastic factories was 83, all of which were in England, except one, employing 24 hands, which was in Scotland. The total number of operatives was 4,438.

A summary showed that the total number of factories, of the kinds enumerated, in the United Kingdom was 7,105, containing 47,388,072 spinning spindles, 5,714,456 doubling spindles, and 725,714 power-looms, and employing 975,546 persons, of whom 374,199 were males and 601,347 females. The number of children working half-time was 51,186 males and 59,399 females.

IRON AND STEEL.—XXVII.

LATEST DEVELOPMENTS OF THE MANUFACTURE.

By William Dundas Scott-Moncrieff, C.E.

IN bringing this series of chapters upon Iron and Steel to a conclusion, we will endeavour, in as short a space as possible, to describe the most recent advances that have been made in the practical production of these metals. But, in order to do this in a way that may be intelligible to the general reader, a passing retrospect is necessary, not only to give an idea of the sequence which necessarily exists in this as in all other departments of scientific progress, but in order to make it clear how it is that what we are about to describe are real improvements, and not merely steps in the dark. And, first of all, we cannot do better than recall the recollection of the reader to the paragraph with which the first of these chapters was begun, because it forms an equally appropriate text for their conclusion. It was there stated, in treating of the "blast-furnace," that the end and aim of the iron smelter is to free the metal from dirt. At the same time, we made use of Lord Palmerston's definition of that term as matter out of its proper place. Now, the more we know about iron the more certain it becomes that, of all the many foreign substances with which it is associated in its native state of ore, there is only one which cannot be looked upon as out of its proper place. This substance is carbon. All the others—silicon, sulphur, phosphorus, oxygen, even manganese—come under the proverbial definition, and ought to be eliminated. If any one of these had happened to be essential to the production of really good iron or steel, it would at once have to be removed from the category of dirt and take its place with the useful substance carbon. As it is, it appears that the last-named is the only ingredient that should be associated with the finest metal. The goal to be reached, then, by the scientific ironmaster is very simple in its character, and may be described in two words—pure metallic iron and carbon. The difficulties in the way of obtaining this desirable result vary according to the original character of the materials employed. If these are associated with many deleterious substances, the process of obtaining good iron becomes correspondingly arduous; and, as it is necessary to employ what may be spoken of as a sub-process in order to get rid of each of them, the dirty ores task the skill of the smelter in proportion to their dirtiness.

It must not be supposed, however, that, even when the greatest success has been attained in the production of pure iron and carbon, that this is all which has to be attended to. As frequently explained already, it is upon the percentage of carbon contained in iron that its character altogether depends, and it is upon very slight modifications of their relationship that the most varied results are obtained. Some idea may be had of how delicate these proportions are from the experience of the late Sir C. W. Siemens, an account of whose contributions to the science and art of the ironmaster will form a conclusion to this chapter. He says:—"Mild steel is a metal consisting of 99·77 per cent. of the elementary substance, iron, and only a quarter per cent. of manganese, carbon, and such impurities as phosphorus and sulphur in the smallest possible quantity." Now, as this proportion of pure iron to all these other substances is only in the ratio of one-fourth part to one hundred parts, the reader may form some idea of the delicate nature of the relationship which exists between iron and carbon, the more so as this small quantity includes all the residue of the other substances which it has been the earnest endeavour of the metallurgist to get rid of altogether.

It is almost certain that, even with the most perfect process for rendering iron pure, a certain amount of one or other of the foreign substances originally associated with the ores, such as sulphur or phosphorus, will continue to adhere to it. The most that can be done is to make the iron as pure as possible; but this absence of perfect purity makes it difficult to estimate the exact percentage of carbon which is necessarily present in different types of what is known commercially as iron and steel. All we know at present is that the type of iron called pig or cast iron contains the largest proportion of carbon, and that, as the carbon is eliminated by being combined with the oxygen of the air, as in the puddling process, the metal approaches and finally assumes the character of malleable or wrought iron, and that, by still further reducing the quantity of carbon, we reach the point in which all the qualities of wrought iron are discovered with regard to ductility and capacity for welding together, with certain special features that are peculiar to "mild steel," and which are

obtained by the addition of carbon in amounts proportioned to the purpose for which the finished metal is intended to be used. Of the manner in which iron and carbon are combined in what is known as cast steel, an account has already been given. In this case a very hard substance is required, such as that which is used for the manufacture of cutting-tools, and the carbon is united to the iron not chemically, but in a graphitic form, in which the carbon to some extent remains a separate substance, offering the same sort of resistance to abrasion that we discover in the diamond. But this subject has already been dealt with, and, as no great changes have occurred recently in its practical application, we will proceed to describe what has been done to improve the process of steel-making in its application to the larger demands of the railway and the shipyard.

In the manufacture of steel two distinct sets of problems require to be solved. The first of these relates to the production of the necessary temperature, and the second to the treatment of the metal while in a heated state. The first of these is essential, of course, to the solution of the other, and forms the foundation of the process. It was to this branch of the subject that Dr. Siemens first devoted his attention, and we must refer our readers to the chapter upon heat-saving appliances, in which the Siemens regenerative furnace is described.* But the production of heat of sufficient intensity to melt the materials out of which the steel was to be made, even in its very attainment, entailed a new set of difficulties, because all the ordinary substances out of which furnaces had previously been constructed were unable to resist the enormously high temperature which the regenerative principle was found capable of producing. Obstacles in this direction delayed the successful introduction of the Siemens process for many years. In a lecture which he delivered before the Royal United Service Institution in 1879, Dr. Siemens spoke as follows in reference to early experiments that were carried on in France:—"The experimental results were on the whole satisfactory. We obtained some charges of metal that was decidedly steel, but, unfortunately, the roof of the furnace soon melted down, and the company who had undertaken the erection of this furnace were so much disheartened that they, for the time at least, abandoned the idea of following up the trials. After two or three very similar disappointments, I decided to erect experimental works at Birmingham, where the processes for producing steel on the open hearth have been gradually matured until they were sufficiently advanced to entrust them into the hands of others. But another French manufacturing firm, MM. Martin, of Sereuil, undertook to erect a regenerative gas furnace that could be used for making steel on the open hearth, but which, in the first place, was to be used as a furnace for heating wrought iron. While I was engaged at Birmingham with experiments to produce steel of good quality by my process, MM. Martin also succeeded in obtaining results with the furnace I had designed for them. At the time of the French Exhibition in 1867, MM. Martin brought forward their excellent exhibits, for which they soon got a considerable name. I also sent samples of steel produced by me at Birmingham, differing from those sent by MM. Martin as regards the materials used in the process. They had turned their attention to the production of steel by dissolving wrought iron in a bath of cast iron, whereas my efforts were directed, from the first, to the use of cast iron and ore for the production of open-hearth steel."

* Chapter x. of this series.

Here we have an account of what has come to be known as the Siemens-Martin process in the inventor's own words, and they will make clear to the mind of the reader how separate and yet how mutually essential to each other are the two divisions in the practice of steel-making—viz., the producing of the heat and the manipulation of the molten mass at the temperature required for its conversion into steel. It was not until the regenerative furnace had been perfected that an opportunity was afforded for obtaining the heat necessary for making steel upon an open hearth; but, although experiments with the new furnace were begun by Mr. Charles Atwood, of Tow Law, so early as 1862, the difficulties that remained to be overcome were so many and so great that they had to be abandoned; and the scene of the operations, which were ultimately crowned with success, is discovered at Sereuil, where MM. Martin had erected a Siemens furnace for the purpose of conducting their own investigations.

The practical operations of the new process, as already stated, were divided between the production of heat in the regenerative furnace and the manipulation of the metal. We must again refer our readers to the description of the Siemens furnace in a previous chapter. It is enough to say that the gas from the producers and the air necessary for its combustion alternately pass through two sets

of chambers made up of intricate passages of brick-work offering an immense surface both for the absorption and radiation of heat, and that, as soon as one of these chambers becomes heated by the passage of the waste heat to the chimney, the other has become correspondingly cooled by the comparatively cold combustible gas and air having robbed it of its heat on their passage to the point of ignition. Before the cooling has gone too far, a set of valves are turned, and the process of heating and cooling the regenerative chambers is reversed, the chamber previously cooled becoming heated by the waste heat being discharged through its numerous recesses on its way to the chimney, and the heated chamber giving out its heat to the air and combustible gas on their passage to the point where combustion takes place in contact with the metal.

When the furnace has in this manner been heated up to the melting-point of steel, or say 3,500° F., it is first of all necessary to see that the bed of highly refractory or unmeltable materials of which the bottom of the open hearth is constructed is all sound and in good working order. If it has become pitted with holes, as the result of the intense heat and the wear and tear of previous charges, white sand which has been previously calcined is thrown in so as to fill up the inequalities, and "heat is allowed to act for eight or ten minutes with the furnace doors closed, by the end of which time the silica or white sand introduced will be partially melted and consolidated with the older portion of the furnace bed."

In describing the process by which the materials are treated in the hearth after it has been thus prepared for their reception, we cannot do better than quote the words of Dr. Siemens:—"These preliminary operations completed, the furnace is charged with say six tons of pig metal, mixed with two tons of such iron or steel scrap as gits, spillings of previous operations, old iron or steel rails that may be available. The furnace doors are thereupon closed, and heat is allowed to act upon the charge for two hours and a half, when it will be found to have fused, and analysis would prove the metal to be in an intermediate condition between pig iron and steel, its percentage of both carbon and silicon being greatly reduced. The subsequent work of oxidation of these ingredients consists in the introduction, at intervals of about half an hour, of rich ores or oxides of iron, in charges of about 5 cwts. each. The immediate effect of the introduction of each charge is an active ebullition, through the reaction of the oxide of the ore upon the carbon of the metal, producing carbonic oxide. This gas escapes to the surface, whereas the iron contained in the ore or oxide becomes metallic, and is added to the bath. When about 25 cwts. of ore have been thus added, a sample is taken from the bath, by means of a small iron ladle, and subjected to a simple mechanical test whereby the percentage of carbon remaining in the metal is readily though somewhat roughly ascertained. If it appears from the test that the carburisation is nearly completed, no more ore is added, but 3 cwts. or 4 cwts. of limestone are thrown into the furnace, which has the effect of combining with the silicon contained in the slag, and of liberating ferrous oxide from the same. . . . . Samples are again taken until the steel smelter finds that, upon breaking the sample, the peculiar silky fibre is obtained which is indicative of the reduction of the carbon in the metal to 0·1 per cent. The metal is now ready for final adjustment according to the strength or temper of the steel required."

Here we have a result very similar in many respects to that obtained by the Bessemer process, which has already been described. In both cases nearly all the carbon is removed from the metal, and, in the words of Dr. Siemens, it is "adjusted" afterwards to the particular purposes for which it is intended to be used. The fact of the same process being adhered to in both cases proves conclusively that up to the present time the art of the steel smelter has not been able to take advantage of any scientific tests that are so expeditious and trustworthy as to enable him to avail himself of them during the short and critical period when his "charge" is reaching the point at which it ought to be removed from the furnace. In the process of puddling no tests are used at all, and the treatment of the metal is so far empirical that the judgment and experience of the puddler are all that can be relied upon in practice to secure a trustworthy result. The scientific metallurgist, invaluable as his labours certainly are in the laboratory, where he provides sure information as to the causes and effects which are at work in the operations of the smelter and the converter, is nevertheless of little service during the few minutes that elapse between the balling of wrought iron in the puddling furnace and its removal at the proper moment to the blows of the shingling hammer. In the Bessemer and Siemens-Martin processes the work is not conducted so empirically. The entire removal of the carbon, which is carried out because no certainty exists as to the exact percentage which the iron contains at

any particular period of the process, and the addition afterwards of a known quantity of spiegeleisen, embraces an element of certainty which has no analogy in the processes that were in vogue previous to their introduction. But honour to whom honour is due. It is not to any of the names that are popularly associated with these great discoveries and inventions that we must look for the real author of what has been found in practice to be essential to their success. Dr. Siemens, who is himself quite as much indebted to the process as Bessemer, acknowledges the service done by the inventor, in his lecture from which we have already quoted. He says:—"But in speaking of this very important process (the Bessemer), I feel in justice bound to make reference to the name of Mushet, who, when he heard of the Bessemer process, thought that it would require an addition analogous to what Heath made in the Sheffield pot-melting process—that of manganese. Mushet proposed and patented a mode of adding spiegeleisen (or pig metal containing a considerable percentage of manganese) to the Bessemer metal whilst it is still in the liquid state, thereby separating from it the oxygen held in suspension in the metal in consequence of the blowing, as we now know, adding to it some manganese, which is essential in order to make the metal thoroughly malleable. We have here, then, a process that has done more than any other invention in modern times to revolutionise, I may say, the most important industries of the land."

It is a somewhat melancholy commentary upon the rough-and-ready justice which is supposed to attend upon human efforts to advance the general welfare, that the men whose labours have been essential to the revolution to which Dr. Siemens refers have neither of them reaped any pecuniary reward. Others, who were profoundly ignorant of the whole subject, and to whose minds the idea of a great benefit to be conferred upon their kind was about the very last to occur, have realised vast fortunes. We refer to those who have been associated with the successful inventors as the possessors of capital. We alluded, in a previous chapter, to the unsuccessful and, as most people now think, the unjust issue of Henry Heath's litigation; and now for the second time, in speaking of the Siemens-Martin process, we feel called upon to mention the unremunerated labours of Mr. Mushet.

From what has already been said, the reader will have gathered that the process for converting iron ores, or iron ores and scrap, into steel depends for its success, in the case of the Siemens-Martin process, first, upon the application of a very high temperature, requiring a special apparatus for its production, and, secondly, upon the open space or hearth being formed of refractory materials to resist the heat, means being provided for manipulating the mass much as in the case of the puddling furnace. The element of a very high temperature has been recently found to be of equal importance to the successful conversion of certain kinds of ore in the Bessemer process. The existence of an unusually large percentage of phosphorus in the Cleveland ironstone rendered it unavailable for conversion into steel for making rails, as the effect of that substance is to make the metal brittle. The Bessemer process is capable of producing a very high temperature in the "converter" from the heat evolved by the oxygen blown through the molten mass combining with the carbon of the charge, but this great heat has hitherto proved fatal to the use of the only kind of lining which has been found capable of eliminating the phosphorus. The world of iron was thrown into great excitement in 1879 by the announcement being made that a successful process had been discovered for removing the deleterious elements of the Cleveland ironstone in the Bessemer converter. The result of introducing a cheap and effectual means for removing these objectionable substances would be to alter the values of a vast amount of the iron ores of the world by bringing those into use which are more readily excavated, to the exclusion of the hæmatite that is at present obtained at great expense. Messrs. Thomas and Gilchrist were the first in this country to devote their undivided attention to the problem of how best to get rid of phosphorus in the process of converting our native argillaceous ores into Bessemer steel, and a great amount of success has attended their meritorious efforts. It is not likely, however, that the result will ever compete in the quality of the products that are obtained from the purer ores of Cumberland. Meanwhile the effect of their labours has been to render the enormous supplies of ores in the Cleveland district available for purposes to which they had previously proved to be inapplicable.

With regard to the prospects of the Great Industry of Iron and Steel, those of our readers who have read these chapters will be well able to judge so far as the outlook depends upon the direction of future improvements. These must inevitably follow upon the same lines as all other scientific forms of

advancement which depend upon the employment of force or heat—namely, economy in the employment of force-producing materials, among which our supplies of coal are the most prominent. All the greatest discoveries to which we have had occasion to refer are so many steps in this direction—the Hot Blast, the Bessemer process, and the Siemens regenerative furnace. Over and above this there are the two great departments of the mechanical engineer and the chemist. Among the achievements of the former we have already described the rolling-mill and the steam-hammer, but an unlimited field for invention is still open in providing manipulative appliances for special industries, such as those we referred to in the chapter on Big Guns. The improvements to be yet introduced by the chemist will probably be the most startling of all. When we consider what strides have been made since the days of Henry Cort, the unrewarded pioneer of the puddling process and the rolling-mill, and how much has still to be discovered, more especially in the direction of cleaning ores from such deleterious substances as sulphur and phosphorus, we cannot help concluding that if progress is to go on in the same ratio in the future that it has done in the past, then we are on the eve of many most important discoveries. Let us hope that the effect of these may be not only to maintain the pre-eminence of our country as the pioneer of advancement, but that they may raise Iron and Steel to the position of a still greater Industry.

WOOL AND WORSTED.—XXVII.

SUPPLY OF RAW MATERIAL AND MARKETS FOR PRODUCE.

By William Gibson.

SIR WALTER SCOTT, the Ettrick Shepherd, and Mr. James Bryden met on a summer evening in 1801 at one of the cosy Cheviotdale inns. Scott had gone into the Border country in search of legendary lore; Hogg and his friend were, for the time being, exercised as to the relative merits of "long" and "short" sheep. "For more than a month," the shepherd exclaimed, "my head has been tenanted by ideas which, though strictly pastoral and rural, are neither literary nor poetical; long sheep and short sheep, tups and gimmers, hogs and dinmonts, have made a perfect sheepfold of my brain, which is hardly yet clear o' them." Thence he launched into a long and learned discourse upon the merits of the breeds, till Scott yawned, and plainly showed how he was bored by the harangue. In one of the pauses of Hogg's monologue, Scott turned to Bryden and said, "I am rather at a loss on this very important question. How long must a sheep actually measure to be called a 'long' sheep?" Bryden, utterly impervious to the joke, replied, in his most serious manner, "It's the woo' (wool), sir, it's the woo' that maks the difference. The lang sheep hae the short woo', and the short sheep hae the lang thing, and they're jist kind o' names we gie them like." Scott's frown relaxed, Hogg's seriousness melted into a smile, the position slowly dawned upon Bryden, and all three burst into a guffaw.

Hogg, however, had started and Bryden summed up the problem that has occupied wool-growers, wool-merchants, and wool-weavers from remotest antiquity. Indeed, with all our scientific appliances and agricultural experiences, there is still the greatest diversity of opinion between the "long" wool and "short" wool schools; but at the time referred to the discussion was exceedingly virulent. There had recently been introduced into this country specimens of the true Merino breed, and the question was, could English wool be improved by crossing the native species, or would our own animals cross with the foreigners, and if so, would it be better to try crossing with long or short-woolled kinds? At first it was thought the Merino—originally brought from Spain by George III.—would neither acclimatise nor cross, but careful experiments and tender nursing overcame all difficulties. The attention drawn to the cultivation of wool by such men as Lord Western and other gentlemen farmers at the close of last century cannot be too highly estimated, for besides leading to wool-growing becoming a science, our native breeds were immensely improved, both as regards the quality of their flesh and the fineness of their coats. It would occupy too much space to go into all the details of the question, but broadly speaking, the outcome of all the endeavours was to bring three or four classes to the front as presenting the most

valuable results. These were the Leicesters, Lincolns, South Downs, and Cheviots. The first and last classes grow wool of a fine texture and medium length; the second, which may be made to represent also the Yorkshire and Hereford breeds, produce long wool, and the South Downs are famous for their short, fine, easily-fulled fibres. By selection and judicious crossing among these classes, combing wool of the finest quality was obtained. When the Merino became accustomed to our northern climate, and began to take kindly to it, a wool scarcely inferior to that of Saxony was got by crossing him with ewes of the new Leicester breed, and this cross is now known as the Anglo-Merino.

One consequence of the better classes of raw material obtainable at home was to give an impetus to sheep-rearing, and another to gradually reduce our imports of wool from abroad. As has been remarked in the course of this series, our chief markets for the finest classes of wool were at one time Spain and Portugal, from which countries all the material for the finest cloths came. But towards the close of last century Germany became the rival of the more southern sheep-farmers, and in course of time supplanted them to a very large extent. Still, English manufacturers in a great measure depended upon home growth for their consumption of raw material. We need not go further back than 1820 to find that the total quantity of wool imported was only 9,789,020 lbs.—a very small proportion of the total quantity used. Of that, 5,113,442 lbs. came from Germany, 3,536,229 lbs. from Spain, and 95,187 lbs. from Portugal. Turkey that year is credited with 189,584 lbs., and Russia with 75,614 lbs. Coming down to 1830, the quantity supplied by foreigners seems large, but the growth of our manufactures accounts for that. In this year Germany sent us 26,073,882 lbs., Spain 1,643,515 lbs., Portugal 461,942 lbs., Russia 202,871 lbs., the total imports from all sources being 32,313,059 lbs. In 1840 the entire buyings from abroad were increased by about 14,000,000 lbs.; but, considering the magnitude which our operations now began to assume, the quantity was not relatively much more than that set down twenty years previously. The most remarkable feature in this year's purchases is the quantity sent from Russia, whose breeds had been gradually improved by an admixture with the flocks of Central Asia. Russia this year sent us 4,518,563 lbs., Germany 21,812,099 lbs., Spain 1,266,905 lbs., Portugal 374,915 lbs., and Turkey 655,964 lbs., the total import standing at 46,224,781 lbs. Some twenty years later—say 1861—our imports rose to the astonishing figure of nearly 135,000,000 lbs., most of which came from our own colonies. By that time we had ceased to buy largely from foreign nations, except alpaca and mohair, and now only small quantities of Continental produce are manufactured by us. Our home supply had, however, been continually increasing till, in 1866, there were no less than 22,048,281 sheep in Great Britain, which yielded probably about 100,000,000 lbs. of wool. In ten years the supply increased 50 per cent., notwithstanding the fact that we could get as much as we required quite as cheaply from our colonies in the Southern Seas. The total number of sheep in Great Britain and Ireland and the Channel Islands in 1867 was 33,817,951, and ten years later there were only 32,220,067. Indeed, the problem that now faces our sheep-farmers is not how much wool they can grow, but how to dispose of their produce, the sheep now being far more valuable for its flesh; and, should the project of bringing live and dead meat from America, and even Australia, be realised on a grand scale, we may in fancy see the time when a sheep will be a somewhat rare feature of the English landscape.

Nor need such a prospect fill us with dismay—at all events, as regards raw material for the woollen industries; for while, as we have just remarked, the first result of improved breeding was to stimulate production at home, it did not end there. This movement was destined to be transferred to our colonies, and to-day the results are almost incredible. The convicts, liberated from durance in New South Wales and Van Diemen's Land in the early years of this century, settled down, as a rule, in those countries, and when they were able, bought a stray sheep from the vessels that called on the ports nearest them. Then they sent to England for better breeds, and began wool-growing on a considerable scale. At length it was thought the climatic conditions of the Cape, South Australia, and New Zealand were favourable to the Merino, an expectation which was amply verified. Last of all, flocks of Cashmere and kindred Asiatic species were sent for breeding purposes, and the result has been carding and combiug wool of the finest qualities and cheapest price. Our earliest colonial wool in any quantity came from the Cape of Good Hope, in 1810. A few months later, a small parcel of 167 lbs. came from Van Diemen's Land and New South Wales. In 1820 we had 13,869 lbs. from the Cape, and no less than 99,415 lbs. from New

South Wales. So far, the wool was coarse, hard, and of inferior quality; but it had been noticed that recently imported English sheep had had an effect, and every year henceforward the quality

The following table will show the quantities imported from our over-sea possessions between 1861 and 1875. The numbers refer to lbs. weight :—

	1861.	1862.	1863.	1864.	1865.	1866.	1867.
A. New South Wales .	16,928,356	17,307,202	21,204,597	24,880,688	25,981,468	36,980,685	21,708,902
B. Victoria	23,923,195	25,245,778	25,579,886	39,871,892	44,270,666	42,390,978	51,314,116
C. South Australia . .	14,578,101	14,497,244	16,568,979	17,496,551	18,945,425	20,908,085	22,633,792
D. West Australia . .	723,965	806,006	1,121,183	550,598	1,358,874	1,234,070	1,312,016
E. Tasmania	2,294,269	5,241,650	4,665,594	4,972,383	4,923,965	4,765,221	4,686,314
F. New Zealand . . .	7,855,920	9,839,265	12,585,980	16,691,666	19,180,500	22,810,776	27,152,966
G. Queensland . . .	6,994,033	8,063,612	10,669,044	14,006,789	12,251,841	14,346,239	21,554,557
H. Natal	647,679	906,823	1,184,845	1,465,254	1,570,192	1,669,415	1,974,447
I. Cape of Good Hope .	24,873,269	25,209,004	31,148,176	36,413,689	32,806,246	35,231,607	36,026,614
J. North America . .	1,554,588	2,066,230	2,475,918	2,986,235	3,079,032	1,784,733	1,764,648
K. India	21,385,429	17,762,415	21,035,919	19,818,726	23,432,689	24,049,643	20,005,483
Totals	121,758,804	126,945,229	148,240,121	179,154,471	187,800,898	206,171,452	210,133,855

	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.
A . . .	25,721,632	51,269,672	47,440,610	65,611,953	50,233,453	31,606,846	75,156,924	87,534,280
B . . .	68,010,591	54,431,367	52,123,451	76,334,480	58,648,977	74,893,882	88,662,284	85,064,952
C . . .	29,629,525	30,532,812	26,218,254	32,656,427	34,650,631	35,973,434	39,844,024	44,508,674
D . . .	1,572,068	1,880,426	1,787,812	1,665,915	1,839,562	1,761,323	2,874,992	2,428,160
E . . .	6,136,426	5,607,083	4,146,913	5,254,719	5,998,527	4,243,433	5,050,920	6,199,248
F . . .	28,875,163	27,765,636	37,039,763	37,793,734	41,886,997	41,587,049	46,855,012	54,401,540
G . . .	18,906,778	22,388,650	20,695,627	22,339,348	17,793,392	19,763,053	20,859,346	20,145,914
H . . .	2,717,381	3,350,437	3,612,501	5,763,999	5,654,416	6,309,573	7,888,994	8,109,447
I . . .	36,489,760	37,224,263	37,283,291	46,609,653	48,841,314	40,394,326	42,620,481	40,339,674
J . . .	1,605,610	2,819,882	2,441,752	2,885,329	3,191,834	3,035,822	2,692,108	2,553,136
K . . .	2,264,967	14,308,278	10,089,709	19,432,838	24,250,904	20,821,652	20,981,198	21,443,135
Totals .	221,929,901	251,578,506	242,879,683	316,348,395	292,990,007	280,390,393	353,486,283	372,728,160

The figures for Australia alone are:—1861, 73,294,839; 1862, 81,000,757; 1863, 92,395,263; 1864, 118,470,567; 1865, 126,912,739; 1866, 143,436,054; 1867, 150,362,663; 1868, 178,852,183; 1869, 193,875,646; 1870, 189,452,460; 1871, 241,656,576; 1872, 211,051,539; 1873, 209,829,020; 1874, 279,303,502; 1875, 300,282,768.

improved. In 1830 we obtained 33,407 lbs. from the Cape; but New South Wales and Van Diemen's Land sold us 1,967,300 lbs. of excellent fibre, or 300,000 lbs. more than we got from Spain the same year. In 1840 the amount credited to the Cape was 751,741 lbs., and New South Wales and Van Diemen's Land sent 8,841,507 lbs. In that same year the firstfruits came from other parts of Australia. There had been small parcels previously, but this year the amount appears in the returns as follows:—Port Philip 785,398 lbs., Swan River 42,748 lbs., South Australia 51,590 lbs.; or, in other words which will bring out more clearly the full significance of the fact, our own colonies supplied one-fourth of the total import, while in 1820 that contribution was one-eighty-fifth. In 1850 the increase was fivefold, and in 1861 Australia alone sent 73,294,839 lbs. The facts about North America, New Zealand, and British India are exactly similar, so it is unnecessary for us to trouble the reader by repeating them.

The significance of the above table will be seen at a glance on comparing it with the total imports from all parts of the world during the same period, including sheep, lamb, alpaca, and llama wools. These imports are as follows :—

	Amount in lbs.		Value.
1862	171,943,472	1862	£11,773,943
1863	177,377,664	1863	11,884,572
1864	206,473,045	1864	15,503,483
1865	212,206,747	1865	14,930,430
1866	239,358,689	1866	17,550.871
1867	233,703,184	1867	16,178.034
1868	252,744,155	1868	15,120,498
1869	258,461,689	1869	14,696,746
1870	263,250.499	1870	15,812,598
1871	323,036,299	1871	17,926.639
1872	306,379,664	1872	18,523,350
1873	318,036,779	1873	19,541,678
1874	344,470,897	1874	21,116,184
1875	365,065,578	1875	23,437,413

The whole of this wool was not made up in Great Britain, for we now sell very largely to

those from whom we previously bought. The exact amount so dealt with between the years 1862 and 1876 is given below, the "excess imports" showing the amount consumed in home manufactures :—

	Exported. lbs.		Excess Imports. lbs.
1862	48,076,499	1862	123,866,973
1863	63,932,929	1863	113,444,735
1864	55,933,739	1864	150,539,306
1865	82,444,930	1865	129,761,817
1866	66,573,488	1866	172,785,201
1867	90,832,584	1867	142,870,600
1868	105,070,311	1868	147,637,844
1869	116,608,305	1869	141,853,384
1870	92,542,384	1870	170,708,115
1871	134,866,304	1871	188,169,995
1872	137,511,247	1872	168,868,417
1873	123,246,172	1873	194,790,607
1874	144,294,663	1874	200,176,234
1875	172,075,439	1875	192,990,139
1876	173,020,372	1876	217,035,387

Among our imports of raw material must now be reckoned woollen rags for shoddy. The following table gives the amount and value for the same period. The quantity in 1876 was over 64,500,000 lbs., valued at more than half a million of money :—

Amount in tons.		Value.	Amount in tons.		Value.
1862	13,109	£437,056	1870	17,210	£400,326
1863	15,417	551,824	1871	24,219	498,754
1864	15,642	642,907	1872	29,302	534,329
1865	14,585	565,861	1873	24,827	468,556
1866	15,797	530,947	1874	25,581	547,399
1867	14,542	395,801	1875	25,415	599,402
1868	15,922	370,412	1876	28,847	660,260
1869	16,699	373,322			

The gross weight and value imported are not materially altered by the goods bought from foreign manufacturers, but for the benefit of disbelievers in free trade, the figures for 1876 may be quoted. In that year we bought 12,909,902 lbs. of yarn, valued at £1,538,496, but at the same time we sold to our foreign customers 30,852,160 lbs. of yarn, worth £4,417,241, the difference in favour of Great Britain being £2,878,745 on this article alone. The fabrics imported in 1876 were as follows :—Cloths and stuffs—Germany, £85,527; Holland, £3,427; Belgium. £46,265; France, £1,766,086; other countries, £2,717; miscellaneous, £3,322,771; total, £5,226,793. The last, and also the largest, item includes all imports of wool and worsteds, not being cloths or stuff goods, from Germany, Holland, Belgium, France, Turkey, Persia, United States, and other countries. Manufactured goat's-hair articles were imported to the extent of £10,505, and manufactured goat's-hair from Turkey and other countries to the value of £873,423. From countries not our own colonies we imported wool valued at £24,203,137, and of alpaca, vicuna, and llama, £364,175. The grand total of imports connected with the wool and worsted industries outside our own colonies, was, in 1876, £32,215,179.

Turning now to the markets we have for our manufactured goods, the figures are equally striking. In 1822, the exports of all kinds of worsted and woollen goods amounted to £6,465,988; 1832, £5,232,013; 1842, £6,271,645; 1852, £8,152,031; 1862, £13,171,946; 1863, £15,520,047; 1864, £18,569,089; 1865, £20,141,415; 1866, £21,830,181; 1867, £20,156,917; 1868, £19,581,388; 1869, £22,669,233; 1870, £21,664,953; 1871, £27,182,385; 1872, £32,383,273; 1873, £25,349,878; 1874, £22,800,952; 1875, £21,659,325; 1876, £18,603,478. The following tables give in detail the number of yards and value of the wool and worsted goods exported in 1877, and show the chief countries to which they were sold :—

Apparel and Slops Exported.

	Value.
Germany	£25,784
Belgium	49,072
France	54,469
United States	51,052
Chili	20,072
Brazil	29,781
British Possessions, South Africa	431,361
British India	82,318
Australia	1,536,158
British North America . .	203,018
British West Indies and Guiana .	89,041
Other countries	261,948
	£2,834,074

Felt Hats.

	Dozens.	Value.
Germany	34,993	£53,062
Belgium	28,904	50,539
France	11,530	21,963
Brazil	10,664	17,067
Argentine Republic . . .	19,312	18,267
British Colonies, South Africa .	23.656	42,512
Australia	163,760	256,441
British North America . .	32,963	61,449
British West Indies and Guiana .	15,645	19,908
Other countries	73,122	119,711
	412,549	£660,919

Broad Cloths, Coatings, Duffels (mixed and unmixed).

	Yards.	Value.
Sweden and Norway . . .	408,973	£63,966
Germany	7,330,120	873,206
Holland	1,436,200	184,740
Belgium	759,344	101,631
France	5,326,371	517,973
Italy	874,850	121,745

Broad Cloths, Coatings, Duffels (mixed and unmixed).—(Contd.)

	Yards.	Value.
Turkey	445,370	£78,669
United States	538,609	149,164
Brazil	364,130	44,542
Uruguay	292,470	39,709
Argentine Republic	436,370	62,226
British India	484,520	45,619
Australia	323,610	51,322
British North America	835,690	135,907
Other countries	1,840,794	266,097
	21,697,421	£2,736,511

Narrow Cloths, Coatings, Duffels, &c. (all Wool).

	Yards.	Value.
Germany	215,360	£55,117
Belgium	266,804	45,274
France	1,732,322	235,486
China	568,170	51,951
British India	251,110	30,967
Australia	1,687,210	248,139
British North America	677,030	84,682
Other countries	1,171,963	161,870
	6,569,969	£913,486

Narrow Cloths, &c. (mixed).

	Yards.	Value.
Germany	538,450	£59,164
Japan	155,730	18,577
United States	161,770	20,224
Brazil	296,920	22,996
Argentine Republic	179,540	15,526
British India	508,130	45,839
Hong Kong	179,510	14,342
Australia	886,900	84,990
British North America	1,251,890	148,237
Other countries	1,728,230	168,470
	5,887,070	£598,365

Mixed Worsted Stuffs.

	Yards.	Value.
Sweden and Norway	4,168,967	£158,639
Germany	17,033,480	613,449
Holland	9,012,320	334,999
Belgium	6,089,470	236,348
Portugal, Azores, and Madeira	1,996,235	86,335
France	34,149,780	1,373,631
Spain and Canaries	1,795,760	73,013
Italy	10,089,000	369,430
Turkey	2,123,480	98,688
China	6,984,610	226,863
Japan	4,034,710	171,232
United States	32,426,320	1,172,286
Brazil	2,480,260	113,721
Uruguay	1,607,910	54,474
British India	1,153,750	44,421
Hong Kong	1,168,460	52,920
Australia	12,456,910	463,082
British North America	17,306,640	569,473
Other countries	9,001,693	357,165
	185,079,755	£6,570,169

Worsted Stuffs (all Wool).

	Yards.	Value.
Holland	582,790	£34,886
Belgium	525,053	26,257
China	6,641,170	421,491
United States	417,490	20,422
Hong Kong	3,168,810	199,405
Australia	2,793,920	183,512
British North America	722,600	43,624
Other countries	2,332,286	137,402
	17,184,119	£1,066,999

Blankets and Blanketing.

	Yards.	Value.
Portugal, Azores, and Madeira	108,385	£8,769
Japan	945,780	88,691
Peru	455,660	82,210
Chili	127,480	19,453
Brazil	1,654,000	142,416
British Colonies, South Africa	424,512	40,362
British India	123,210	7,557
Straits Settlements	97,800	8,678
Hong Kong	156,910	20,861
Australia	1,418,910	156,889
British North America	538,499	58,890
Other countries	734,029	75,209
	6,785,175	£709,985

Flannels.

	Yards.	Value.
Germany	121,490	£9,167
Japan	147,760	9,061
British Colonies, South Africa	389,834	21,389
British India	847,590	37,808
Hong Kong	162,640	9,435
Australia	5,817,700	291,451
British North America	1,189,170	55,888
Other countries	597,245	32,193
	9,273,429	£466,392

Carpets.

	Yards.	Value.
Sweden and Norway	135,207	£18,093
Germany	448,289	71,510
Holland	369,008	55,174
Belgium	248,727	33,173
France	856,347	104,315
Spain and Canaries	278,060	33,577
Italy	176,329	20,030
Japan	195,030	20,363
United States	515,992	88,104
Peru	114,050	15,895
Chili	227,780	28,439
Australia	1,118,475	135,125
British North America	1,137,300	141,554
Other countries	633,855	82,411
	6,454,449	£847,763

Shawls.

	Number.	Value.
France	43,198	£15,760
United States	101,443	38,261
Colonies, South Africa	22,366	5,967
British India	86,816	18,254
Australia	48,004	15,941
British North America	65,219	19,067
Other countries	124,667	35,542
	491,713	£148,792

Rugs, Coverlets, and Wrappers.

	Number.	Value.
Germany	65,420	£31,681
France	46,433	16,281
Italy	29.517	7,701
United States	55,971	13.728
Argentine Republic	53,365	10,392
Brazil	399	132
Colonies, South Africa	65,760	12.597
Australia	68,919	29,589
Other countries	170,803	60,737
	556,587	£182,838

Hosiery.

	Value.
Germany	£26,519
Holland	7,916
Belgium	9,981

Hosiery.—(Contd.)	Value.
France	£68,596
United States	14,947
Colonies, South Africa	8,352
Australia	77,149
British North America	44,762
Other countries	35,389
	£293,611

Small Wares, Wool and Worsted.

Sweden and Norway	£25,872
Germany	54,530
Holland	33,584
Belgium	30,201
France	53,642
British India	32,434
Australia	36,499
British North America	13,755
Other countries	98,529
	£379,046

Alpaca, Mohair, and other Yarns.

Germany	£220,193
Holland	154,055
France	248,584
Other countries	26,414
	£649,246

The above tables, in round numbers, represent 106,000,000 lbs. of wool, at a gross value of £19,168,008. The exports to Australia include Australasia generally. To sum up, then, the imports and exports for 1877 stand as follows, in round numbers:—

Imports.

Wool	400,000,000 lbs.
Yarn	12,000,000 „
Rags	64,500,000 „
Foreign Sheep	3,000,000 „
British Sheep	32,000,000 „
Total	511,500,000 lbs.

Exports.

Wool	173,000,000 lbs.
Goods	106,000,000 „
Yarn	30,000,000 „
Total	309,000,000 lbs.

This leaves, in round numbers, for home consumption something like 202,500,000 lbs. of wool. Of the total exports, our own colonies in India, South Africa, Canada, and Australasia consumed goods to the value of £7,310,933, leaving £11,857,075 to those nations with whom we do business. We already saw that we exported 30,852,160 lbs. of yarn, worth £4,417,241, and 173,020,372 lbs. of wool, worth in round numbers £12,000,000. The total export trade in 1877, therefore, was no less than £28,274,316. Or, in other words, we paid foreign countries, outside our own colonies, £4,000,000 of money more than we received on our gross transactions in wool and worsted. But that estimate, true as it is in gross, does not truly represent the case. The net results are as follows:—We bought yarn to the amount of £1,538,496, and manufactured textures valued at £5,246,453—total £6,784,949. On the other hand, we sold foreign nations a quantity of yarn valued at £4,417,241, and of manufactured goods £11,857,075—a total of £16,274,316. This leaves a balance in favour of British manufacturers of no less than £9,489,367. The remaining item is that of wool. While we took from abroad to the amount of £24,000,000, we only sold in return half that amount. Still, raw material does not compete with finished products, and even if this were admitted, while the countries from which we got the wool send us nothing else, we sell them our manufactured goods from every industry in the kingdom; and, looked at from this point of view, they pay us more than the £12,000,000 which we lose on wool.

We have now done. The Wool and Worsted department of England's Great Industries, it has been abundantly shown, has made giant strides within a comparatively brief period of time, and its power of production is yet fully equal to every demand that may be made upon it.

INDUSTRIAL ART.—IX.

ART IN GLASS.—SECOND PAPER.

By John Forbes-Robertson, Author of "The Great Painters of Christendom."

It is proposed in this, the concluding chapter of this series, to glance in the first place at Ecclesiastical Glass Painting, and secondly, but briefly, at glass objects of familiar use and ornament, with the view of showing how these are affected by the laws of taste as expressed in colour and design.

Colour, like tone in music, to which, as Professor Tyndall has shown, it is curiously akin, and to whose co-relation science will one day give a precise formula and an intelligible nomenclature, has been an important and impressive element in religious ceremonial and temple decoration in all

ages. Seeing shares with hearing the honour of being the most immediate, comprehensive, and spiritual of all our senses, and none have appreciated more thoroughly the value of these direct avenues to the soul than the hierarchy of Rome.

Before the pseudo-classic art of Palladio had reached England and revolutionised her architecture in the early years of the seventeenth century, our great pre-Reformation churches, it must be remembered, were usually floored with variously coloured and patterned tiles; nay, the very walls were coloured after a crude fashion, and on every pillar were designed appropriate subjects from Scripture. But it was not till colour, hitherto flat and dead, became in the mediæval window united and glorified with light, that its full potency was felt. This iris-like refulgence, conjoined with the complementary chiaroscuro inherent in Gothic architecture, with its darkling mystery further enhanced by clouds of smoking incense, and the heavenly music of unseen minstrels, predisposed the mind to devotional reverence, and almost breathless awe. But however variegated the floor, and however interesting the Scripture incident or saintly legend set forth on the pillar or the wall, it was to the window that the penitent mostly turned in the intervals of his devotions; its rays exalted everything on which they fell, and their radiancy prefigured the "things eye had not seen nor ear heard," which were to be his hereafter. The incense might disperse, the quiring might cease, the voice of the preacher become mute, but the windowed glories of the emerald and the amethyst, the topaz and the ruby, however unexpectedly their rays might flit or their brilliancy change, were never absent from the sanctuary, and their contemplation brought a chastened joy alike to the master and the serf.

Now, it is precisely this primary quality of prismatic brilliancy, chromatic translucency, which we have to keep in view, when we come to fix approximately the limits within which the glass-painter must work. A necessary condition of all art-practice and progress, as has been frequently urged in these papers, is a thorough knowledge of the nature and limits of the material in which the artist works. Make the most of its virtues, but never give its faults an opportunity. This seems obvious enough when written; but, when we consider how frequently it has been forgotten, the simple canon cannot too often be re-stated.

The art of glass-painting found its earliest western home in France, and on the authority of the Abbé Texior, Winston is inclined to place its cradle in or near Limoges, always famous for its enamellers. A Venetian colony was settled there as early as 979, "for the purpose of trading with the spices and other commodities of the East, conveyed from Egypt by way of Marseilles." These settlers brought their Oriental tastes with them, and accordingly many of the churches in the neighbourhood bear marks of Byzantine influence. Greek artists, it seems, were living there in the thirteenth century.

Whether the treatise on glass-making and glass-painting found in the second book of the "Diversarum Artium Schedula" of the monk Theophilus, belongs to the tenth, or only to the early years of the thirteenth century (some authorities, not without reason, fix the date about 1220), it is evident from the book itself that the art must have been practised for generations before he could have penned so exhaustive an exposition of its mysteries. So minute and perfect, indeed, is his description of how to make painted glass windows, that his method is almost identical with that followed at the present day by the art-workmen of our great glass houses. I was particularly struck with this when watching the various processes in the workshops of the Messrs. Powell. It was here, by the way, that Winston made his analytical investigations and discoveries, and he bears ample testimony to the truthfulness of Theophilus in his every statement as to the materials and colouring matter used in glass-making.

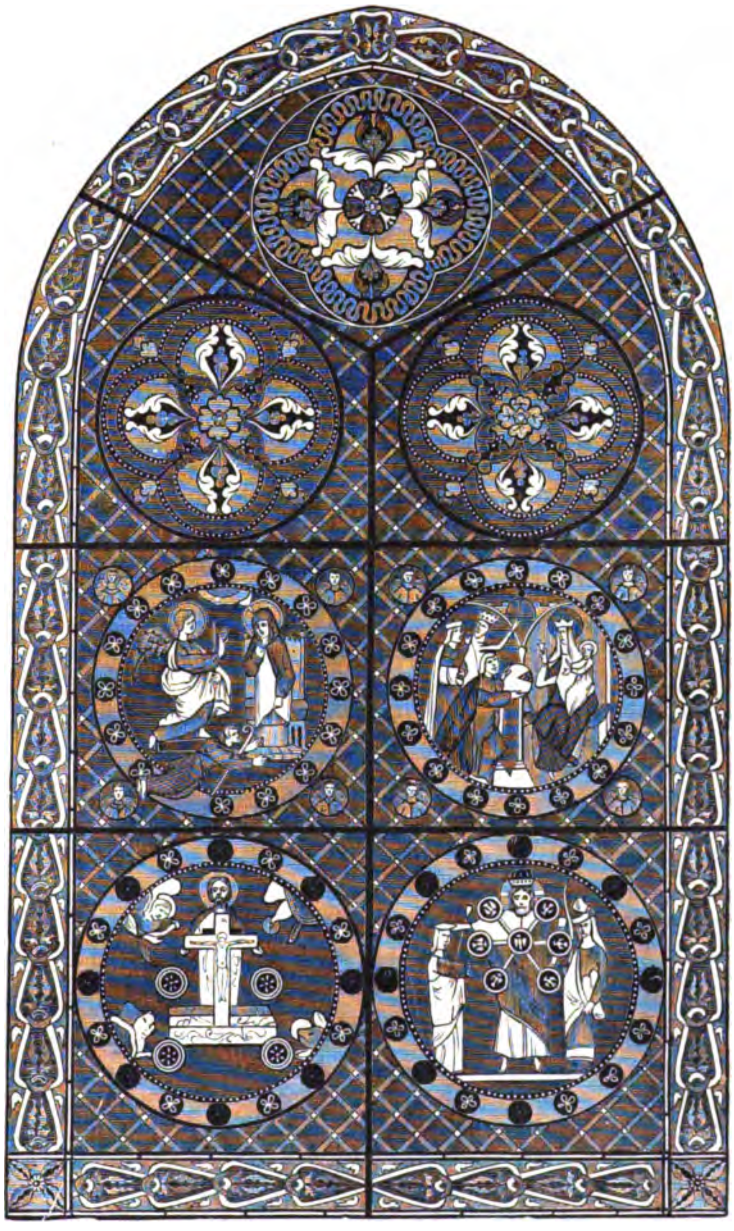
The art of window-glass colouring has known two grand epochs—the first, that of mediæval times, say during the twelfth and thirteenth centuries; and the second, that of the Renaissance, embracing the last half of the fifteenth and more especially the first half of the sixteenth century. The former, with its mosaic intensity and bald directness of design, may be said to have typified the power of the Church; while the latter, more sensuous in colouring, more flowing in line, and ampler and richer in composition, was expressive of its splendour.

So far as authenticated examples go, the Mediæval epoch was at its best between 1150 and 1250. The figure parts of the composition at this time were flat, but by no means lacking in a certain Byzantine dignity as to the face, and in the earlier instances in respect of the drapery also. The foliaged ornament was almost entirely conventional. France is the great storehouse for glass of this remote period; but England is not without examples of nearly as early a date. The Jesse window

in Canterbury Cathedral, and part of another Jesse in York Minster, which, according to Winston, has been inserted into the tracery lights of the Decorated clerestory windows of the nave, belong to the last half of the twelfth century, and are not inferior in quality to the French glass.

After responding in some measure to the naturalistic movement of Cimabue and his school, improving in its foliage treatment, but substituting for what remained of the old Roman dignity of the face the lugubrious visage prescribed by clerical conventionality, the art gradually deteriorated, until it revived again in the early part of the sixteenth century under the irresistible and all-pervading influence of Masaccio and his followers.

During all these intervening years glass-painting loyally followed the various styles of architecture. The Norman, or, as it is now called, Byzantine, or Romanesque, with its round-headed openings, as seen in Durham Cathedral, was superseded by the Early English, or Pointed, with its long lancet-headed windows, like those in Lincoln Cathedral, and especially in Witney Church, Oxfordshire, in the last quarter of the twelfth century. Then, in the last quarter of the thirteenth century, came the Decorated, made for ever famous by the beauty of its Eleanor crosses. This, in its turn, gave way to the Perpendicular, known by its transomed windows and fan-tracery vaulting, towards the end of the fourteenth century. This last of the Gothic styles, called by the French Flamboyant, and sometimes Burgundian, had a slightly longer lease of life than its predecessors, and flourished till 1530; Henry the Seventh's Chapel is a characteristic example. Then came the Tudor, and so on. It must be remembered, however, that the dates given are only approximate. There was much overlapping, and the line of demarcation did not always admit—in such cases it scarcely ever admits—of being traced with mathematical exactitude.



WINDOW IN THE CATHEDRAL OF ST. DENIS.

Now every one of these styles had its character set forth in glass as well as in stone, and an educated antiquarian would be able to fix for us the date of a building as truly by a piece of its painted glass, from its colouring, its heraldry, its lettering, or its art, as by a piece of its stone moulding or tracery.

But the glass-painter, while thus adapting his work to the changes in architecture, was also very careful to note the advancing phases of fresco and oil-painting; and the history of pictorial art, either on the wall or on canvas, is almost identical with the history of the same art upon glass.

Winston arranges the mediæval Picture Windows into three classes:—(1) *Medallion Windows*, "in which some connected story is told by a series of pictures set in medallions, which are arranged throughout the window in a geometrical order," and such windows are generally placed in the nave and choir of cathedrals; (2) the *Jesse Window*, frequently occupying the west end of the nave, "in which our Saviour's genealogy is represented by a series of figures encircled or enclosed within flowing scrolls of foliage;" and (3) the *Figure and Canopy Windows*, in which is represented a figure standing under a canopy. Such windows are, on the whole, peculiar to the clerestory. Of *Pattern Windows* our authority makes a distinct class, and, as their name implies, they consist of an ornamental pattern. They are always less rich in colour than the Picture Windows, and their place is generally "in the pierced triforium, when such exists, or in some of the windows of the apsidal chapels, where, perhaps, light was an object."

The Medallion Window which requires, according to Winston, a width of some four or five feet for its due development, was abandoned when the mullioned window came into use—say, during the Decorated period; and when transoms, or horizontal mullions, came into fashion with the Perpendicular style, the favourite design was the figure and canopy window, and often beneath each canopied figure was a coat of arms, or a group of figures representing the donor of the window and his family.

Colouring remained almost equally deep and powerful down to the accidental discovery of the yellow stain, which was made about 1310. Oxide or chloride of silver is its chief ingredient, or rather pure silver ground with pipe-clay, or venetian red as a vehicle, and as soon as this delicate yellow became a common possession the whole scheme of colour was altered by changing the key to a higher note. This paler character of colour did not find its fullest expression, perhaps, till the fifteenth century, and the fourteenth holds a middle place between this and the mosaic depth of the thirteenth century. In early practice the outlines and shadows of a design were painted by means of a flux with an enamel colour, something similar to our "enamel brown." Strongly pronounced black lines represented the deep shadows, and a very slight wash of enamel indicated the half tints. But towards the close of the fourteenth century the lines diminished in thickness and intensity, and were retained only as outlines, the deep as well as the light shadows being represented by a "stippled" coat of enamel brown, which was spread all over the glass. Previously the enamel brown was "smeared" over those parts only which were to be in shadow. The early painters, however, had advantages over their immediate successors in the very nature of the glass they used. Each colour in twelfth and thirteenth century glass was deep and harmonious in itself, and consequently, as was pointed out in the chapter upon coloured textiles, the effect was always good in whatever way the colours happened to be arranged. Mediæval artists, moreover, showed their wisdom by "avoiding subjects which could not be intelligibly represented by a few figures arranged in one plane, like the figures in a bas-relief, and placed on a stiff background of blue or red, trusting to the glass itself to do the rest," and a practice of this kind we should like to see much more followed in our own time than it is.

But during all this period, however good the colour, its scale was limited, however graceful here and there the lines, the effect of the figures was flat, and their attitudes strained and conventional. As time went on, fresh tints were discovered, and they were used with greater pictorial knowledge. Men began to forsake the old beaten paths, and launch forth, literally and metaphorically, into new regions, and exercise their faculties on far wider fields than any known to their fathers. Glass painters felt the thrill of the new life, and, in the joyous consciousness of its strength, they carried their beautiful art to its culmination. This, the second grand period of glass-painting, to which allusion has been made, coincides, therefore, with the great art-revival, known to us as the Renaissance. Whatever improvements the famous masters of Italy introduced in the delineation of nature soon found their way across the Alps, and none were more eager to take advantage of them than the glass-painters of France and Germany.

In drawing and modelling—which latter implies a mastery over light and shade, and in pictorial qualities generally—the art very soon eclipsed anything done in the mediæval period. The seven eastern windows of the choir of Lichfield Cathedral —which windows "belonged originally to the Abbey

of Herckenrode, in the old episcopal principality of Liége," and, coming into possession of Sir Brooke Boothby, Bart., were presented by him to the Dean and Chapter of Lichfield—are considered the finest examples we have in England. They are of the Italian-Flemish school, and were executed, as the dates upon them testify, between 1532 and 1539.

This cinque-cento style in glass-painting, which was concurrent for a while with the Perpendicular in architecture, commenced about 1500 and ended in 1550, rising and falling, as it were, with the Renaissance; for, while Michael Angelo was still alive, decadence had already commenced, and from much the same cause which affected oil-painting—viz., the endeavour, on the part of glass-painters, to accomplish more than their art could compass, and from emphasising and exaggerating the mannerisms of some favourite master, instead of going, like him, for renewed strength to nature. We must always keep in mind, however, that the early sixteenth century glass-painters, with their improved glass and greater technical knowledge, had attained great beauty of design, and carried to its legitimate culmination in broad, rich harmony, the low-keyed mosaic intensity associated with the name of the mediæval monk Theophilus.

But the art of glass-painting knows a third revival, and that belongs to our own time. It commenced about a generation ago, and was the outcome of the impetus given to the study of mediæval art by the writings and practical example of such men as Sir Walter Scott and Welby Pugin, the first symptoms of the coming fever manifesting themselves in the pseudo-Gothic of Horace Walpole, first described in his "Castle of Otranto," and then bodily realised by him at Strawberry Hill.

An earnest and influential party in the Church took advantage of the prevailing taste, and gave to the movement a decidedly ecclesiastical turn; but when the windows of their Gothic churches came to be filled in, the artist in glass was nowhere to be found, and, in default of better men, those who first embarked in the art or manufacture—for it was scarcely either the one or the other in its earlier days—were glad to content themselves with porcelain-painters from the Potteries. We had no window-designers artistically bred, and when work of importance had to be done, we had to seek for them beyond the seas. The necessity of having to stoop to so sorry an alternative arose in this wise. While we on this side the Channel were giving to glass-painting a clerical bias, there was a city in the centre of Europe which took up this branch of art, as it did every other, purely for its own sake. Under the enlightened countenance and practical encouragement of Lewis I. of Bavaria and his family, the chief city of his kingdom soon rose to be the art-capital of Germany, and in this our nineteenth-century Renaissance the cultured people of other lands than those watered by the Iser know that glass-painting, like fresco, has Munich for its *alma mater*.

When a great national work, therefore, had to be undertaken in this country—viz., the glazing of the windows in Glasgow Cathedral—those concerned had no help but to send to Munich. It was there alone that artists of sufficient training could be found to make the cartoons. Von Hess, Strahüber, Von Schwinde, and the like had, in this particular walk, no compeers in England; and it is curious to note what the best judges thought of the productions of Ainmüller then, and what we think of them now.

The late Charles Winston—whom we have frequently quoted in this chapter, and who has, by his writings and enthusiastic devotion to the practical study both of the science and the art of the subject, done more for the revival of glass-painting in this country than any other man that could be named—thus speaks of the windows of Glasgow Cathedral to the famous glass-painter, Ainmüller, of Munich:—

"I have no hesitation in declaring that, in my humble opinion, when we consider the high art displayed in the figures, and the skill shown in the execution of these windows as glass-paintings, the windows of Glasgow Cathedral are absolutely unrivalled. No modern work approaches them, and, upon the whole, they are certainly superior to any ancient work. . . . Each of your windows is as perfect a harmony of colour as the finest old window can be pronounced to be; but the difference is that in your windows the harmony is in a high key of colour, whilst in the old windows the harmony is in a low key of colour. Now, a harmony in a low key of colour is undoubtedly more agreeable than a harmony in a high key; and so thought that prince of colourists, Titian; for it is remarkable that all his blues, greens, yellows, reds, and indeed all other hues, are low in tone, and are by no means pure colours. You should therefore endeavour to prevail upon your glass-maker to furnish your establishment with glass of a lower tone, especially with green, blue, and red—these being the three colours, and particularly the two first, which most

struck me as being too high in key in the Glasgow windows." In another letter to his friend Wilson, he says—"Whether it is owing to my sense of colour being more shrewdly tickled by a perfect harmony of colour in a high key than in a low one, or whatever else the cause may be, I confess I was more pleasurably affected by the harmonies of the lighter colours in some of these windows than I ever remember myself to have been by those of the old ones." In the meantime Winston himself was carrying on in the workshops of the Messrs. Powell, of Whitefriars, those chemical inquiries into the texture and colour of ancient glass which have resulted in making English glass, both as to quality of metal and colour, the finest in the world.

The letter from which we have quoted was written in 1861, and on the 3rd of October, 1864, the devoted Winston went over to the majority. But during these few intervening years how marvellous are the strides we have taken in the art of glass-painting! Were it possible for Winston to go now from the contemplation of any of our later masterpieces—say, for example, Burne Jones's Waltham window—back to his beloved windows in Glasgow Cathedral, he would scarcely believe that these were the veritable glass-paintings about which he had written so enthusiastically scarcely twenty years before. Burrow, Holiday, and our other painters, are no longer what the designers of Winston's time were, timid imitators of others, but men whose creative faculties, coupled with their sympathetic knowledge of line-sweep and form, entitle them to be called masters in their art.

Pellucidness we have described as an essential quality in painted glass; but Munich artists have taken to painting on the surface so much that the transparency is killed, and instead of holding the light as fine horny glass ought to do, this over-painting prevents the light coming through, and leaves an effect on the eye almost suggestive of a window-blind transparency. The Munich school also makes use of a blue enamel which is painted on the surface of white glass, whereas we use a pot metal in which the blue strikes right through instead of being on the surface. Again, instead of using flesh-coloured glass for the face and hands, as is the practice here, the Munich school mixes for that purpose an enamel white with an enamel pink—a method which, like the other, we look upon both as illegitimate and ineffective, seeing that it interferes with the primary qualities of painted glass, transparency and brilliancy.

It is this forgetfulness of first principles which has led to so many deplorable failures in glass-painting. The straining after the effects of oil-painting on canvas by the excessive use of enamels is almost painfully illustrated by what Horace Walpole called the "washy" virtues of Sir Joshua at New College Chapel, Oxford—an expression applied to the effect in the painted glass, and not, we presume, to Sir Joshua's original design—and in the great east window and south window of the aisles of St. George's Chapel, Windsor, as well as in the windows of Arundel Castle. It is true these windows were executed when glass-painting was at its nadir; still, there are not wanting those in our own country, and more especially in Germany, who persist in forgetting that a glass-painting must transmit light, while all that is required of an oil-painting is to reflect it. Well might Winston say that those who attempt to make glass-painting rival in all respects oil-painting, attempt an impossibility; and when the attempt has been made, he might have added, the result is an absurdity. Once more, then, *art-method must always be in sympathy with the material whose virtues it would glorify*.

M. Bontemps, the famous French practical authority on glass, and who was perhaps the only one connected with the jury which pronounced on the merits of the glass-painting exhibited at our first great International Exhibition of 1851 who really understood the subject, was the first to revive the brilliant ruby of the thirteenth century. But since then experimental chemistry in this country has effected an almost boundless enlargement of its borders. A generation ago, our young students who were attracted to chemistry used to look forward with apprehension to the limited character of the sphere in which there was any prospect of their earning daily bread; but now there is scarcely an industry in the country which does not find its account in securing the services of a well-salaried chemist.

Now, in this matter of colour, Powell of White-friars and Chance of Birmingham can make ruby glass equal to the ruby of any period. Nay, the very mellowness of age—for time gives the same rich tone to painted glass which it gives to painted canvas—and those peculiar physical characteristics which cause it,—namely, the little refractive cells with which the atmospheric action of ages almost honeycombs a much-exposed window,—such firms as Burlison and Grylls and Clayton and Bell can, by a skilful application of hydrofluoric acid, reproduce

with as much certainty as the learned manipulators of wines can reproduce the beeswing of "old port."

This chemical facility, however, has its drawbacks, and the designer with such glass at his command is apt to reproduce with a slavish and pedantic literalness the pitiful flatness and lugubrious asceticism of the visage, the anatomic grotesqueness in the action as well as in the lengthening of the limbs—in short, the mingled ecclesiastical conventionalism and art-ignorance which characterised the pictorial efforts of the Middle Ages. Even when a modern glass-painter has to replace a missing window—say of the fourteenth century—with something of his own, we should deprecate such total abnegation of the time being. By all means let there be a certain harmonious assimilation of the new to the old, but not such as to lead one to suppose that the artist's main object was to baffle the power of distinguishing the one from the other.

But when the painter has to deal with a new church he has no excuse whatever for confining himself to mere imitation. While following conscientiously the spirit of the style adopted by the architect, let him eschew altogether such archæological pedantry as would compel him to follow every petty detail he may fancy identified with the period. We have seen that there is no hard and fast line in any age dividing one style from another. We often note in the same building a prophecy of the changes to come, and a fond lingering here and there over favourite features that have already become the property of the past. Without violating mental association, then, let the painter be perfectly true to the spirit of the period chosen by the architect; but at the same time let him not be disloyal to the technical knowledge, the enlightenment and thought, characteristic of his own.

Let the glass-painter make the best of his difficulties. He cannot ignore his leads, but he can throw them so skilfully into the outlines that their presence would be rather welcome than otherwise. They themselves, indeed, would become the outlines, and by their very strength and boldness give a rugged emphasis to the whole composition. Nor must the iron saddle-bars, which are so essential in keeping the window in its place, be thought a deadly hindrance to art-expression. Let them be frankly accepted, and let both the design and the colour be adapted to the necessity. In the scheme of colour the saddle-bar often plays an important part, and its pronounced opacity gives measurable value to the whole.

MURANO GLASS.

In this same matter of colour the present generation has attained to a very exquisite sense of it since Winston's time. He had little idea of it apart from its association with figure-design. The design or figure pattern with him was the first thing, and the colouring the second; at all events, he had little idea of colour away from pattern. He complains of medallion windows "seldom having their design more made out than that of a Turkey carpet, to which they are often likened."

Now, I have shown in a former chapter, when speaking of textiles, that there are such things as *colour*-patterns, and to the current taste, therefore, a medallion window having the effect of a glorified Turkey carpet would be rather grateful than otherwise. If our mediæval medallion-painters were not over-careful to preserve the distinctness of their composition, so long as the colouring was properly massed and related, they only followed the promptings of an instinct which may have been inherited from their remote ancestors, and afterwards brought into educated activity by intercourse with the dwellers in Eastern lands. It is curious that the Chinese at this very moment manufacture by the thousand a parasol which is one harmonious blaze of colour, and the casual gazer looks upon it as colour, and nothing else;

but if he regard it attentively for some time, he will discover in most cases that there is a beautiful figure-design in it, generally showing two elegant female forms, illustrative, no doubt, of some legend belonging to the Flowery Land. Such a colour-pattern as this, with the figures waiting to be sought for instead of immediately taking bodily possession of the spectator, might, in our opinion, be used with great advantage in a medallion or even in a rose-window. The colour, as a matter of course, would be the first thing to attract the eye, which, after bathing itself in the soothing refulgence of a rose-window, let us say, would not be the less pleased and impressed to discover that it could evolve from the chromatic glory an angel's head or the benign face of the Blessed among Women.

Treatment of this kind is by no means confined to painting; the kindred art of poetry often delights in the mysteriously vague and some of its greatest beauties arise rather from what it suggests than from what it actually expresses.

Turning to domestic glass, such as vases, ewers, bottles, beakers, bowls, cups, wine-glasses, and whatever, in short, admits of ornamental treatment, we find a more complex set of conditions attending its manufacture; and now that Salviati has discovered some of the old Venetian processes, which, in their turn, were only re-discoveries of methods more ancient, the field for art-application is simply boundless. There is no material in which man works which is so brilliantly obedient to his will, and scarcely an object in nature, from the rolling cumuli in the heavens to the dewy flowers in the field, which he cannot make it imitate. Even the form and iridescence of the matrixed opal, the scintillation of the polished gem, the warm whiteness of the pearl, it assumes under his controlling hand. He can give to it the aspect of the hardest granite, or convert it into a handful of the airiest and flossiest silk.

When the artist has thus at his command form, colour, brilliancy, and transparency, there is no achievement beyond his reach. And when it is remembered that he can make his pattern penetrate the very substance of the glass itself, as is seen in the interlacing of white or coloured spiral lines in the stem of a Venetian wine-glass; or, as was done by the Egyptians thousands of years ago, that he can throw layer over layer, as in the Portland Vase, and work on the surface as in an Italian cameo; or, that he can cut it, engrave it, spin it, colour it, and gild it, the reader will at once see that glass is the most amenable to art treatment of all substances known to us in nature.

The same æsthetic laws which have been propounded from time to time in these chapters apply to the glass worker. His manipulative processes must be of the daintiest kind; but the instruction of his fingers must be accompanied by the education of the mind, and in all that he does he must ever keep before him not only the variety and perfection, but also the modesty of nature.

POTTERY AND PORCELAIN.—XI.

THE WORCESTER ROYAL PORCELAIN WORKS.

By James Francis McCarthy.

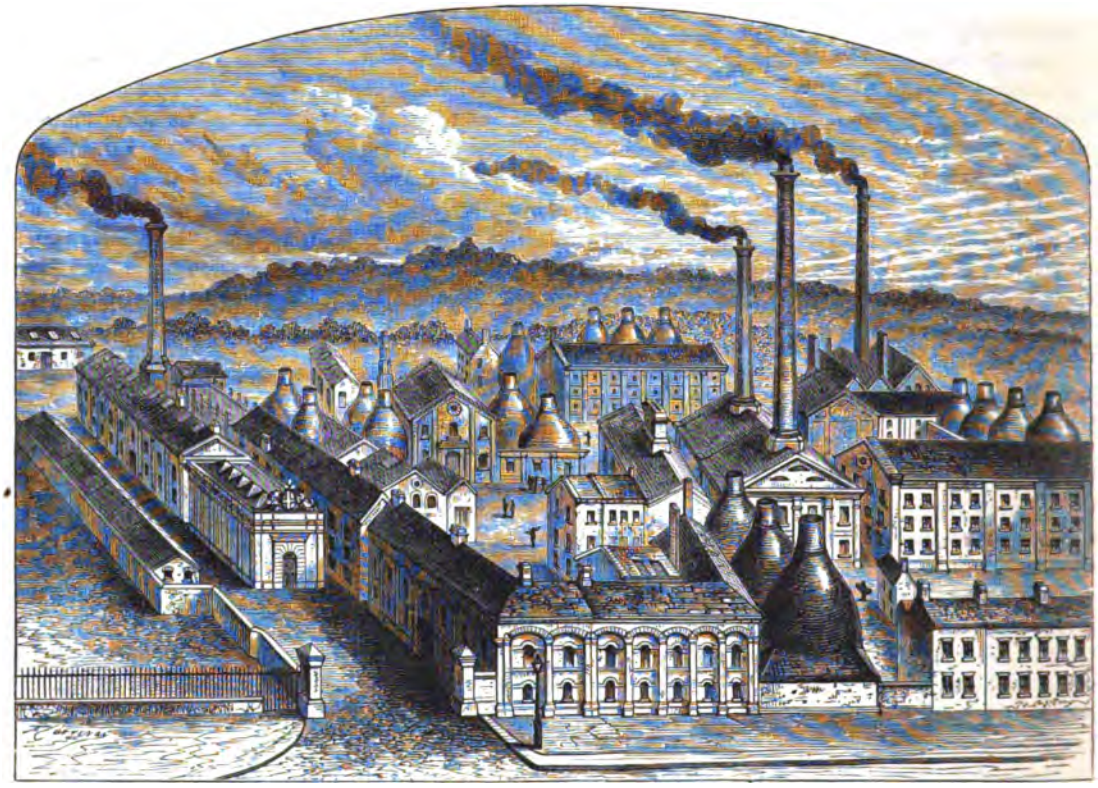
ALMOST under the shadow of the cathedral, nearly flanked by it on one side, and surrounded in every direction by cheerful scenery, stand the Worcester Royal Porcelain Works. Unlike what is witnessed in North Staffordshire—where in the day-time a canopy of smoke darkens the face of Nature, and in the night tongues of fire flicker in bands of fierce light across the sky—the ceramic industry in Worcester is carried on under brighter natural influences. In these Worcester Works the labour of the day is performed in the midst of pleasant scenery, and with no evidence of that fierce, high-pressure effort which makes its influence and its physical evils so strongly felt on toilers in large manufacturing towns.

The Worcester Royal Porcelain Works, to lovers of the ceramic art, possess a peculiar interest, and the history of the place, in this the last chapter devoted to the potters' industry, may appropriately bring the series to a close. One hundred and thirty years ago, when the manufacture of porcelain was attracting so much attention abroad, when royalty took it under its patronage, and when the wealthy and the great became charmed with its influences, the English Court, although a little behind its Continental neighbours, turned its

admiring attention to the most fascinating industry which ever gave occupation to human hands. As many people may be aware, the Porcelain Works at Bow and Chelsea, in the Georgian era of England's history, enjoyed a considerable reputation, and this was not undeserved, for specimens of the work which were produced at these establishments, and which still exist, are not devoid of beauty, although necessarily they lack that perfect finish associated with the best descriptions of porcelain manufactured at the present time. Whilst the industry was exercising this influence it was only natural that men of culture and learning—especially if the learning embraced a sound knowledge of chemistry—should turn their thoughts to the manufacture of porcelain. This is what the celebrated Dr. Wall, the founder of these works, did; and in doing so he created a new industry for the ancient city of Worcester. In 1751, and for some years previous the cloth trade, one of the staple industries of the place, had ceased to exist in the city. The manufacture of gloves and carpets, which were the two remaining sources of occupation for the people, did not give sufficient employment. Then Dr. Wall, who was a skilled physician, a chemist of great experience, and an accomplished artist, happily thought of starting a new industry—that devoted to the manufacture of earthenware and porcelain. In the same year the works were founded as a company of which Dr. Wall was the chief. It is true that Worcester possessed no coals, no clay, nor, what is more important still, any skilled potters. But these difficulties were overcome, as all difficulties are ultimately overcome when they are faced as Dr. Wall met them, with the strength of a determined will. Minerals were brought from a distance, and by means of the canal were carried close to the manufactory. Workmen were engaged, and then commenced in earnest the manufacture of earthenware and porcelain. For thirty years after its formation Dr. Wall continued to be the guiding and controlling spirit of the company. During this period some beautiful porcelain was produced, remarkable then, as their work is now, for the fineness of its body, its lightness, and its translucency. Artistically, the designs, which at this time were nearly all painted in blue, partook of an imitation of Chinese decoration. About four years after the establishment was opened, transfer printing—a process which has been already described—was introduced. This printing, which at that time created no little astonishment, was effected with black designs on the glaze, and with blue prints under the glazed surfaces. Some specimens of this kind of work—specimens rendered costly by their rarity and an old-fashioned quaintness in the style of their treatment—show that this printing was applied to a variety of articles. It appears on the covers of knick-knacks, on the backs of snuff-boxes, in the shape of medallions, on buttons even—in fact, on anything which bore an enamel surface. The designs, judged even by the critical standard of the present time, evidence unquestionable originality, and almost faultless workmanship. A few years later still we find the enterprise and quick judgment of Dr. Wall aiming at more ambitious efforts. At that time the porcelain manufactured at Dresden, and especially at Sèvres, was creating profound admiration—admiration that came alike from royalty, peers, and commoners. By many it was thought impossible that such beautifully formed ware could be even approached in an imitative sense. Dr. Wall, who did a great deal to elevate English pottery, showed that porcelain almost as good as that made at the State-supported manufactory in France, could be produced in Worcester. In dinner and tea services some beautiful ware was made, bearing all the evidences of delicate manipulation and gossamer-like construction so conspicuously noticeable in Sèvres porcelain. But Dr. Wall was no copyist; he imitated his French rivals only in the purely mineral nature of the ware, in its lightness and wonderful translucency. Constructively as well as decoratively the ware, like that made to-day, has certain characteristics which are peculiar to all Worcester porcelain. Dr. Wall died in 1776, and the remaining partners continued to carry on the works until 1783. In this year the establishment was sold to Mr. Flight, of London, and for eleven years his two sons conducted the business. It was during this particular period that George the Third visited the works, and granted his warrant permitting it to be called "Royal." In 1793 Mr. Barr was taken as partner in conjunction with Mr. Flight; and fourteen years afterwards Mr. Barr, junr., was added to the firm. On the death of Mr. Barr, senr., in 1813, a younger son was introduced into the business, and the name of the firm was changed to Flight, Barr, and Flight; although, as a matter of fact, Mr. Flight died in 1829. In 1840, after many changes, a joint-stock company was formed to conduct the business; but in eight years afterwards the company was dissolved, and the firm became that of Walter Chamberlain and John

Lilly. Two years later another change of proprietorship took place; and in 1862 a joint-stock company was formed, and has continued ever since. Of this company Mr. R. W. Binns, to whose skill and enterprise in late years the success of the establishment in a great measure was due, became the managing director.

Since the works were started great changes have naturally taken place. Time after time the old building has been altered and extended, so that now the works cover about three acres of ground. They give constant employment to about six hundred workmen, and the total number of kilns is fourteen. That which strikes the visitor to this manufactory is the peculiarly open nature of the workshops. The different rooms, unlike what is to be seen in many similar manufactories, do not crowd on each other; but in every direction there is breadth, light, and freedom. As is the case at Minton's, all the shops are scrupulously clean, and as the place is in the heart of one of the most genial stretches of landscape in the country, there is, so to speak, a calmness and a repose in the manner in which the labour of the day is performed. In passing through the different shops, and beginning in proper order with the "slip-house"—the place, it may be remembered, where the clayey ingredients are in their liquid state—it is observable what extraordinary care is taken in the final stages of the preparation of the enamel-slips. When the slip is drawn from the vats it passes through iron tubes which run round the room and discharge their contents into a long trough, from whence it flows into the vat again. This trough from beginning to end is filled with moderate-sized magnets placed in rows. The object of this is to attract all minute particles of iron which may be left in the liquid clay. A glance at the magnets after the slip has slowly passed through the trough, shows at once the result. The tips of the magnets are simply "furred" with these particles of iron. The operation could be repeated *ad infinitum*, and the oftener the slip passes through these magnetic troughs the purer it becomes. If these particles of iron were not extracted from the "slip," they would appear, after firing, as so many black "specks" on the surface of the ware, and of course would materially deteriorate



THE WORCESTER ROYAL PORCELAIN WORKS.

its value. At the Worcester Works the greatest care is exercised in preparing this liquid clay, as the finished articles, if they are to sustain the reputation of the firm, depend so much for their excellence on its quality. There is another custom in connection with the mixing of the soft clay, which is not, as far as can be ascertained, adopted at any other porcelain manufactory. Mixed with the mineral and chemical ingredients is a quantity of pulverised black bone, and not white bone, which is ordinarily used. The effect of this mixture is to give the soft clay a dark appearance very much resembling the colour of slate. When the ware is "fired," and it is in its biscuit state, it looks only a shade less white than when it is made with an admixture of ordinary pulverised bone.

In one long, wide room, with low ceiling and beams running across it, the operation of "throwing" and "turning" may be witnessed. The work of "throwing"—which, simple as it looks, claims a history that carries us back to primeval days, and which is spoken of in the poetically majestic language of the Bible—is not made a special feature of at these works. It is done well, but there is no attempt at that exquisite symmetrical finish, that gracefulness of proportion and outline, which in Grecian and Roman pottery were distinguishing features, and which Wedgwood tried and often succeeded in imitating. The work of "casting," on the other hand, is performed with much skill, as the statuary ware testifies.

In the manufacture of statuary, particular care has to be taken in the "casting," and this is especially evidenced in all such articles produced at these works. The different sections are made in the moulds with much delicacy, and they are pieced together in the manner already mentioned with a careful patience that is almost surprising in these days when rapidity of mechanical effort seems to be the absorbing idea. The result, however, of all this painstaking labour is that the work possesses exceptional merits. The political statuary of the company is an interesting branch of their business. The familiar features of Mr. W. E. Gladstone, Mr. John Bright, and of other well-known Liberal statesmen, have been fashioned in terra-cotta with surprising realism. The bust of Mr. Gladstone is a fine specimen of this description of statuary. As most of us have seen it in life, it is stamped with that intense look of earnestness and sincerity which at once strikes everyone who has heard the illustrious statesman, when, in the impassioned fervour of his oratory, he carries irresistible conviction to the mind, at the same time that he strongly appeals to our sympathies and emotions.

One of the special features of these works is the production of ivory Japanese porcelain. This speciality takes the form of large vases; and its originality chiefly consists in the enamelling which so perfectly imitates ivory. This imitation is obtained by a combination of certain chemicals in the liquid enamel known only to the manufacturer and those who have to co-operate with him in the work. The subjects which serve to illustrate the ware are all taken from Japanese nature, both animate and inanimate. Very weird much of this decoration appears: dragons, lizards, serpents, and curiously-formed reptiles twine up the handles of huge vases and coil themselves round the covers. Another series of vases very happily picture the manufacture of pottery in China. This illustration, which is brought out in relief, is chiefly effected by means of the moulding process. On the sides of the vases are given different views of the mechanical processes of pottery. For instance, there is a sketch of the potter of the olden times, throwing a vase; of the moulder; of the painter; together with a view of the kilns. The work is remarkably elaborate, and of its kind is certainly unique. Of a different kind, but none the less a triumph of the potters' skill, are some magnificent opaque white enamel vases, in close resemblance of Limoges ware. The charm of these vases consists not so much in the nature of the ware itself as in the manner in which it has been decorated by the late Mr. Thomas Bott. The subjects illustrate the Norman Conquest, after drawings by Maclise from the Bayeux Tapestry. Words can but feebly indicate the perfect art with which every figure has been traced, and is burnt into the ware so as to give it enduring vividness. So realistic do all these historical figures appear, that they seem to live again on these vases. And how finely they are drawn! The face of Harold in every line indicates the warlike spirit which stamps it with such hostile earnestness. To produce these effects, the process of enamelling, after the artist had performed his task, entailed exacting labour, and the "firing" of the vases, which are worth £1,500, was a matter which created prolonged anxiety. To give some idea of the artistic labour which was bestowed on these vases, it may be stated that the time occupied in painting them was about two years. But if these vases are costly, how much more so, in a relative degree, are the famous cup and saucer

made for the late Earl of Dudley, and valued at fifty guineas! As they are essentially gems of porcelain, they merit a word or two of special notice. The cup is no larger, perhaps not quite so large, as an ordinary tea-cup, and the saucer is in proportion. They are both very light—so light, that when placed on the hand you can scarcely feel that they are resting there. The decoration is marvellous. The ground-work is of deep gold, and the idea is to imitate turquoise jewelling. By the aid of small globular particles of enamel, which are afterwards touched with paint, the imitation turquoise is produced; and they are arranged with such painstaking and elaborate care that the lines of turquoise seem to converge in graceful and accurate lines to one central point. The beauty of the work is a beauty of that order which, when once seen, is a constant recollection. The cup and saucer are shown in a morocco and velvet case, like a valuable porcelain jewel, as they really are. There is still another kind of work for which the Worcester manufactory has gained well-deserved popularity, and that is what is known as the pierced china work. Close to the edges of any given article which has to be treated in this manner, certain defined spaces are traced in the soft clay, which have to be pierced with a small steel tool that thus causes the necessary little apertures. This is quickly done, and the effect is very pretty.

The painting at these works does not differ in the mode of execution from that which may be seen at other prominent establishments of a like character. But it does in some respects materially differ in degree: it may be considered to be more conventional, and it has (as might be expected) its own characteristic features which, naturally enough, one does not find so noticeable elsewhere. Moreover, at the Worcester Royal Porcelain Manufactory there is almost an entire absence of foreign artists. The artists at these works are brought up from boyhood in the place, and are trained there. Although the painting is to such a large extent conventional, it is nevertheless very perfectly done. The painting of landscape and animals evidences as much exquisite skill and refinement as probably may be seen anywhere else. Besides, such great care is taken in the firing of the best kind of ware, that the artist's work invariably shows up with happy effect.

With this account of the Old Worcester Porcelain Works, as has been already intimated, the description of pottery and porcelain may appropriately terminate. It was at Worcester that this industry received a healthy impetus, and some time before even Wedgwood's fame was becoming recognised, Worcester china had made its charm felt. This charm has not faded with the lapse of time and the keen competition of æsthetic rivalry in other parts of the country. The Worcester china which was made in the days when Doctor Wall was in the zenith of his power, is to-day regarded as a ceramic treasure which has become so rare that only the few can hope to possess it. Of the fascinating nature of the industry which creates all this work, those only who have seen it in all its varied and beautiful branches can have any idea. It combines labour with art so perfectly and so purely; it gives ever-changing facilities for the dexterous ingenuity of the hand; it opens up a wide field of experiment to the chemist; and to the artist it is profuse in its bounty. Of all other industries, there is none like this which gives to the artist such infinite and exhaustless scope for the realised play of his fancy, and for that skill which transfers to common clay, sketches of life and landscape that live and look beautiful long after the mind that conceived them has been at perfect rest from all this world's busy labours.

FOREIGN RIVALRIES.—XIII.

NEW CONDITIONS OF RIVALRY.

By H. R. Fox Bourne.

In the previous chapters of this series we have seen how in all our more important industrial pursuits, and especially those which are considered most necessary to the continuance of our nation's wealth and material welfare, we already find ourselves, and are likely to do so more and more, opposed by the successful competition of other countries. The conditions of industrial rivalry have altered greatly during the past two or three generations, and are liable to so much further

change that, if we are to maintain our present position, we must boldly and zealously adapt ourselves to them.

We may no longer trust to the original advantages enjoyed by England in having more accessible, and, therefore, for all practical purposes really greater, stores of coal and iron, seeing that in other countries coal mines and iron mines have been opened up, and in some districts, especially in America, are being found to be even better stored and more accessible than our own mineral treasuries. Nor may we trust, as our forefathers were justified in doing, to any special commercial facilities possessed by England for either bringing to its shores the rough produce of distant countries or sending abroad the finished manufactures of our own. It is true that we still obtain vast supplies of raw cotton from the United States and elsewhere, woollen fibres from Australia and South America, flax and its vegetable allies from New Zealand and other parts, silk and kindred animal fabrics from China and the East. It is true also that we still distribute over the world vast quantities of these materials wrought into all sorts of useful commodities, together with the woollen and linen products of our own sheep farms and flax gardens; and there is no reason why we should not continue the same pursuits and continue to profit immensely by them. But other nations are learning our crafts. We have taught them to make, as well as we can make them, if not better, the tools of every kind, from knives and needles to the most complicated varieties of machines, by which we formerly excelled in nearly every branch of manufacture; and, if we still claim supremacy on the sea for our merchant navy even more than for our ships of war, our trading vessels are now quite as available for carrying the produce of other countries from one to another without yielding any other gain to England than comes from the merchants' freights, as for the older uses to which they were almost exclusively put in the direct service of our manufacturers and their customers.

Nor may we count, even if we were selfish enough to desire it, on our industrial supremacy being long maintained by what may be called the moral causes which have thus far contributed to it. We are reasonably proud of the superiority of the English workman, as regards both strength of nerve and strength of muscle, over the workmen of all other nations, and, in spite of all the allegations of unfriendly critics, we need be in no fear as to its continuance. In his work on "Foreign Work and English Wages," Sir T. Brassey, an authority not to be controverted, quotes, among other weighty evidence, the testimony of the highest authority of all in the iron trade concerning the relative value of French and English labour in furnaces. "Mr. Lowthian Bell," he says, "took infinite pains to obtain correct data as to the quality of the work and the quantity of iron made at each furnace. He found that at the furnaces on the Tees twenty-five individuals performed an amount of work identical with that executed by forty-four men at a French furnace. In spite, therefore, of the wages being, as nearly as he could estimate, twenty per cent. cheaper, the cost of the labour employed in smelting a ton of iron was sensibly greater at the French works than at Middlesborough." So it is in other trades; nor is there any more warrant for the common assertion that English labour is deteriorating from its former standard than that it is being surpassed by foreign labour. "In 1861," says Sir Thomas, "the industrial census discovered that 385,000 miners were employed to cut 86,000,000 tons of coal, showing an average of 223·3 tons of coal raised per man. Last year, however, 494,000 miners raised 134,610,000 tons of coal, being an average of 272·4 tons per man." Altogether, we may endorse Sir T. Brassey's satisfactory verdict: "I retain an implicit faith in the British workman: if he will but do himself justice, he is as capable as ever he was of holding his own against the world." At the same time we must remember how much that "if" involves, and that there are other elements of uncertainty to be taken account of in forecasting the future. However much the working classes in this country may be in some respects ahead of those abroad, it is evident, and we ought to rejoice, that the foreigners are improving in many ways, and that every advance they make, beneficial as it is to them, to their nations, and to the whole world, marks the necessary lessening of England's special advantages unless English workmen continue to improve in like manner.

There is at least one other point too important to be passed by. Not only has our country reason to be proud of the service it has done in stimulating the industrial energies of other nations and in encouraging their working classes to ameliorate their social condition: its strictly political influences have also been considerable, and among these what most concerns us here is its successful promulgation of free trade doctrines. At present, the general complaint is that foreign nations, our

American kinsmen, and even many of our colonial fellow-subjects, are still so blind to the advantages of a policy of free trade; nor can it be denied that their protective systems, failing to help on their own industrial progress, except now and then in the most artificial and ephemeral ways, are also injurious to us by stopping up some of the legitimate outlets for our manufacturing and commercial enterprise. When the wise doctrines of free trade are everywhere fairly understood and fully acted upon, however, we must not expect their adoption to secure any exceptional benefits for ourselves. Free trade, when it is universal, will help England by cheapening the prices of many commodities and facilitating the distribution, wherever there is need of them, of all those articles which each separate district is best able to produce; but in so far as Englishmen have hitherto derived special advantages from their holding of free trade doctrines, they will, in a sense, suffer by the general extension of those doctrines throughout the world.

The time is surely coming, and it cannot come too soon, when all the civilised portions of the globe will be in as intimate relations with one another, and as mutually serviceable to one another, as are now the several districts of our own country. In old days nearly every town had its separate crafts and its separate monopolies and was jealous of all the rest. More recently, as numberless worn-out charters obtained by royal favour and nearly as many extinct Acts of Parliament attest, special families and particular localities had exclusive rights in carrying on certain trades, and certain mining and manufacturing operations. Of this the most notable instances, perhaps, occur in the prolonged efforts that were made to restrict woollen manufactures to English soil, and the utmost that philanthropic statesmen like the first Earl of Halifax and his friend John Locke could think of doing for Ireland was to attempt to develop linen manufacture in it by artificial means as a compensation for the continued prohibition of all trade in wool. All such arbitrary restrictions have long since been abandoned within the kingdom itself, and now Belfast and Dundee, Glasgow and Manchester and all our other manufacturing centres vie with one another without any legislative or fiscal interference. If special localities offer special facilities for particular enterprises, they are of course there carried on most successfully, but Englishmen, Scotsmen, and Irishmen are alike free to resort thither and to take any part for which they are competent in the prosperous work. More than that, both British capital and British labour are now largely employed in manufacturing and mining as well as trading occupations in France, Belgium, Italy, Austria, and other parts of Europe, to say nothing of America and our Colonies, while in return many foreigners make similar use of England, though at present rather for commercial and financial than for strictly industrial purposes. These movements will certainly spread widely and rapidly, and philanthropists may joyfully look forward to a not very distant day when, without any considerable weakening of whatever is healthy in national characteristics and patriotic impulses, all barriers of idle prejudice and unreasonable jealousy will be broken down, and cosmopolitan interests will happily bind together both diverse races and diverse classes. The stupendous political advantages of such an advance in civilisation, the new meaning it will give to the phrase, "*Imperium et Libertas*," need not here be considered; but it is quite pertinent to our subject that we should duly apprehend the revolution it will inevitably bring about in the conditions of industrial rivalry.

As that revolution has already begun, all the experience of recent years tends to show the folly and mischief of attempting to resist the laws which guide it, and, on the other hand, the wisdom and profit of honestly conforming to them. It is easy to understand, and we may partly excuse, the mistaken policy by which many of our continental neighbours and our American cousins, as well as even some of our colonial fellow-subjects, seek to build up in their own districts various industries adapted to those districts, but which, it is thought, could only grow slowly in them, if they would grow at all, without the help of artificial restrictions and artificial stimulants. A striking instance of the successful results, for a time at any rate, of a policy of protection, appears in the planting and development of the sugar industry of France, now extended to adjoining countries, where, perhaps, without some such protection, the beet-root of the temperate regions might never have been able to become a formidable rival of the sugar-cane of the tropics. Less justifiable, because here the workings of natural causes could have been more safely trusted to—but, from their apologists' point of view, quite permissible—have been the efforts of well-meaning statesmen in America to secure for their own country by imposing prohibitions on foreign manufactures, all the advantages of working

up at home the mineral wealth of its northern districts and the prolific produce of the cotton-fields in the south. Thereby the United States are giving hot-bed vitality to the rivalship with England in every sort of machine-making, and in the production of all sorts of cotton fabric, which could not have failed to become overwhelming in time. As Englishmen we may complain of the blow which is thus inflicted upon our iron and cotton industries, and which we may justly regard as an injury because it is inflicted prematurely. As economists we may regret that the Americans should have injured themselves as well as us by forcing into manufacturing undertakings much labour and capital which, in the present state of their country, might have been employed in agriculture with greater advantage to the country itself as well as to the rest of the world. But we must admit that the speculators and politicians of the United States are only hurrying on a crisis which must necessarily come sooner or later, and for which we are bound to prepare ourselves. It is the same with a multitude of other cases that might be adduced.

Without excess of boldness we may roughly forecast, if not the industrial future of England, at any rate the altered conditions under which—from the causes briefly indicated above and repeatedly suggested in the previous chapters of this series—our industrial rivalry with other nations, if it is to be beneficial to ourselves, or even to them in any real sense, must be carried on.

It cannot be too clearly understood that many of the old conditions are no longer in force, that the former elements of our industrial prosperity, and of our industrial supremacy in some respects over all the rest of the world, are dying out. There is no appreciable diminution in our supplies of coal and iron, but other peoples have discovered that they have equal or greater stores of this wealth, and that they can work it as well as, if not better than, we can work ours. We have greater facilities than ever for bringing to England all the raw materials that our country does not itself produce, and for conveying to every market that requires them all the commodities we manufacture, but these facilities will be of less and less importance to us as our former customers get more and more into the way of manufacturing for themselves the commodities they need, or of obtaining them, with equal facility, from manufacturers nearer to the sources of the raw materials. Already many countries, which for a long time procured from us large quantities of metal work and hardware of all sorts, of cotton, woollen, and other textile fabrics, and of much else which they needed, are making these things for themselves or obtaining them from other markets; and this is the case not only with the United States and the most advanced portions of Europe, but also with distant customers like the Chinese and Japanese, and with the inhabitants of our own colonies and dependencies, like India and Australia. We may be glad to think, with Sir T. Brassey, that "our industry has not yet been beaten on a large scale by foreign competition in any case in which that competition has been carried on under identical conditions, both as to natural resources and fiscal legislation," but we must remember that everything is tending to place us at a disadvantage with foreign producers except as regards those materials for manufacture which are the "natural resources" of England, and that when fiscal legislation reaches the ideal state of recognising absolutely free trade, it will do no more than place us on an equality with our rivals. Unless we are prepared to see our country gradually lose the dignified and profitable position it has hitherto held as the chief manufacturer for all the world, a position by which it is enabled to maintain within itself a population far larger than its own sources of food supply can keep alive, and dwindle down into the rank of a mere producer of machines, clothing, and the like for its own inhabitants and for such foreign customers as cannot get what they want more cheaply and conveniently from the other industrial centres that are competing with us, we must insist that it complies with all the new and nobler conditions of industrial rivalry which are superseding the old and rougher ones.

What are those conditions? A few instances may help the reader to discern them for himself.

In the first place, let it be noted that science—and art, which in this respect is only a branch of science—is every day becoming of more importance in all industrial pursuits. It was by crude apprehensions of scientific truths, with more or less artistic deftness, that all the old tools, the first spades and knives and needles, the original spinning-jennies and mining appliances, and all other agents for developing mere manual labour into manufacturing energy, were invented and discovered. All the improvements made on the old instruments have been the results of scientific and artistic skill, a constant effort to produce machines more suitable than any previously in use for the mechanical and artistic work to be done. It was by

their readiness in exercising this inventive power that Englishmen made all such trades as cotton manufacture, and the production of all machinery, from household utensils and small farming tools up to agricultural implements and mills and steam-engines, especially their own; while the daintier eyes and fingers of the French, for example, gave them almost a monopoly in silk manufacture, and, to take another illustration, enabled them to share with the Swiss nearly all the old business of watch-making. Are Englishmen now as careful and as eager as they should be to maintain all their former superiority in certain crafts, and to emulate their rivals in all others? In a word, do we recognise the vast importance of technical education, both for the training up of inventors and for the fitting of all working men and women to make the best and most scientific use of all the inventions brought within their reach? Our future industrial prosperity depends not a little on this.

No less important is it that our working classes should be in other respects properly educated, both physically and mentally. Our industrial prosperity thus far has been in great measure due to their exceptional strength of limb and vigour of body, to their powers of endurance and persistent application. Foreigners are learning from them the value of wholesome food and other hygienic prescriptions in increasing their working powers, and thus really cheapening labour though at the cost of augmented wages. It is alleged, on the other hand, that the English artisans and labourers are falling into wasteful and luxurious habits, by which their wages are largely squandered in useless luxuries, if not in indulgences that are positively detrimental to their health and working powers. This surely needs correction. The highest wages that the working man can earn, and these can only be decided by almost unalterable economic laws, are fairly his due. But he is not the only sufferer, if he fails to make proper use of his wages in promoting the happiness of himself and those dependent upon him, and in making himself in every respect as good a workman as he can be. The laws of health are among the subjects with which he should thoroughly acquaint himself; but no branch of education that can raise him intellectually and morally, as well as physically, can be dispensed with if he is to take his share in maintaining the industrial prosperity of his country.

Nor does our industrial future depend on the working classes alone. As much, if not more, responsibility rests with the employers and capitalists, who co-operate with them for their own and other nations' welfare. Do they thus cooperate now? It is the masters, as often as the men, who cause strikes and other obstacles to the steady progress of our industries. The masters need to be educated equally with the men. If they understood their duties to themselves, no less than to their employés and to society at large, a new order of things would be initiated. Perhaps that new order of things would lead to the breaking down of all arbitrary distinctions between masters and men, between capital and labour even, as the terms are now understood. But, if so, that would be only an earnest of the industrial prosperity of England both in the near and in the remote future. If all who are engaged in those pursuits on which, more than on anything else, depends the well-being of the country, can be persuaded to work together for a common object which aims primarily at securing for each and all among themselves the full reward of honest toil and intelligent enterprise, and, joined therewith, the fulfilment of the paramount duties of good citizenship and of genuine philanthropy, every separate industry adapted to the nation's capacities must necessarily thrive. And all that thrift means happiness and prosperity for the whole nation.

GENERAL INDEX.

A

B

C

D

E

F

L

M

N

O

P

Q

R

T

Y

Z

THE END.

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